



NUREG/IA-0089
PSI-Bericht Nr. 91

International Agreement Report

Post-Test-Analysis and Nodalization Studies of OECD LOFT Experiment LP-LB-1 With RELAP5/MOD2 CY36-02

Prepared by
D. Lübbesmeyer

Paul Scherrer Institute (PSI)
Wurenlingen and Villigen
5232 Villigen PSI
Switzerland

**Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555**

October 1992

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
and Application Program (ICAP)

Published by
U.S. Nuclear Regulatory Commission

NOTICE

This report was prepared under an international cooperative agreement for the exchange of technical information. Neither the United States Government nor any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use, or the results of such use, of any information, apparatus product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

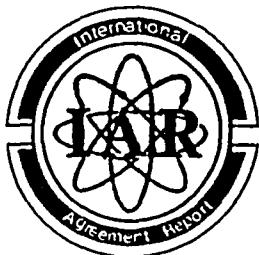
Available from

Superintendent of Documents
U.S. Government Printing Office
P.O. Box 37082
Washington, D.C. 20013-7082

and

National Technical Information Service
Springfield, VA 22161

NUREG/IA-0089
PSI-Bericht Nr. 91



International Agreement Report

Post-Test-Analysis and Nodalization Studies of OECD LOFT Experiment LP-LB-1 With RELAP5/MOD2 CY36-02

Prepared by
D. Lübbesmeyer

Paul Scherrer Institute (PSI)
Wurenlingen and Villigen
5232 Villigen PSI
Switzerland

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

October 1992

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Thermal-Hydraulic Code Assessment
and Application Program (ICAP)

Published by
U.S. Nuclear Regulatory Commission

NOTICE

This report is based on work performed under the sponsorship of the Swiss Federal Office of Energy. The information in this report has been provided to the USNRC under the terms of the International Code Assessment and Application Program (ICAP) between the United States and Switzerland (Research Participation and Technical Exchange between the United States Nuclear Regulatory Commission and the Swiss Federal Office of Energy in the field of reactor safety research and development, May 1985). Switzerland has consented to the publication of this report as a USNRC document in order to allow the widest possible circulation among the reactor safety community. Neither the United States Government nor Switzerland or any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability of responsibility for any third party's use, or the results of such use, or any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

Abstract

Experiment LP-LB-1 was conducted on February 3, 1984, in the Loss-Of-Fluid-Test (LOFT) facility at the Idaho National Engineering Laboratory under the auspices of the OECD. It simulated a double-ended offset shear of one inlet pipe in a four loop PWR and was initiated from conditions representative of licensing limits in a PWR. Additional boundary conditions for the simulation were loss of offsite power, rapid primary coolant pump coastdown, and UK minimum safeguard emergency core coolant injection rates.

This report presents the results and analysis of ten post-test calculations of the experiment LP-LB-1 by using the RELAP5/Mod2 cy36-02 computer code with different nodalizations; these calculations have been performed within the International Code Assessment Program (ICAP). Starting with the "standard nodalization" as more or less used by the code developers at EG&G, for different nodalization studies, we have reduced the number of volumes and junctions (especially in the pressurizer, the steam generator secondary side and the intact loop) as well as the number of radial zones in the fuel rods.

Generally, the code has calculated most of the thermohydraulic parameters of the LOFT-experiment LP-LB-1 within an accuracy of approximately $\pm 20\%$, but always has underpredicted the cladding temperatures up to a value of 150 K. Except for the cladding temperatures, only small discrepancies have been observed between the results of calculations using different nodalizations. Reduced numbers of volumes and junctions usually have decreased the running time of the problem but in one case, due to numerical instabilities even has prolonged it a little bit.

The time behaviours of the cladding temperatures have been significantly affected by the chosen nodalizations but surprisingly, the results for the cases with a reduced number of volumes and junctions seem to be slightly closer to the experimental data.

With respect to top-down rewetting, one of the key-events of experiment LP-LB-1 during the blow-down phase, RELAP5/Mod2 was not at all able to predict this phenomenon.

Contents

1	Introduction	5
1.1	Short Description of the LOFT Experiment LP-LB-1	5
1.2	The Aim of the Present Investigations	8
2	Nodalization Schemes Used to Analyse Experiment LP-LB-1	10
2.1	Standard Nodalization	10
2.2	Stripped Nodalisations	14
3	Results	19
3.1	Experimental Results	20
3.2	Influence of the Nodalization on Computer Time and Mass Error	23
3.3	Discussion of the Code-Predictions of the Main Events	26
3.3.1	Calculation of Mass Flows in the Broken Leg	28
3.3.2	Minimum Collapsed Liquid Level	37
3.3.3	Emptying Points of Pressurizer and Accumulator	37
3.3.4	Peak Cladding Temperatures During the Blowdown Phase	37
3.3.5	Quench Front Positions During the Reflooding Phase	38
3.4	Time Behaviour of Significant Thermo-Hydraulic Parameters	39
3.4.1	Cladding Temperatures	39
3.4.2	Fuel Center Temperatures	69
3.4.3	System Pressures	69
3.4.4	Fluid-Temperature in the Downcomer	73
3.4.5	Core Mass Flows	76
3.4.6	Core Average Liquid Fractions	76
3.4.7	Mass-Flow Out of the Broken Loop	81
3.4.8	Intact Loop Mass Flow and Pump Speed	85
3.4.9	ECC System	89
3.5	Investigation on the Prediction of Top- Down Rewetting	96
4	Conclusions	106
5	Appendices	109
5.1	References	109
5.2	Listing of RELAP5/Mod2 - Input Mk. 6-00C	111

List of Figures

1.1 LOFT components showing thermo-fluid instrumentation	6
2.1 Nodalization 6-00/6-01 of the LOFT system (most detailed version;	11
2.2 Detail of the nodalization of the LOFT core	12
2.3 Nodalization 8-00 / 8-10 of the LOFT-system	15
2.4 Nodalization 8-03 of the LOFT system (most simplified version;	17
3.1 Measured cladding temperatures in center bundle 5	21
3.1 Measured cladding temperatures in center bundle 5	22
3.2 CPU-time to Real time ratio vs. time	25
3.3 Mass error as defined by RELAP5/Mod2 vs. time	27
3.4 Trip setpoints for experiment LP-LB-1	28
3.5 Hot-channel cladding temperatures vs. time at axial level 02	40
3.6 Hot-channel cladding temperatures vs. time at axial level 11	42
3.7 Hot-channel cladding temperatures vs. time at axial level 21	43
3.8 Hot-channel cladding temperatures vs. time at axial level 24	44
3.9 Hot-channel cladding temperatures vs. time at axial level 27	45
3.10 Hot-channel cladding temperatures vs. time at axial level 31	46
3.11 Hot-channel cladding temperatures vs. time at axial level 39	47
3.12 Hot-channel cladd. temperatures vs. time at axial level 43.8	48
3.13 Hot-channel cladding temperatures vs. time at axial level 49	49
3.14 Hot-channel cladding temperatures vs. time at axial level 62	50
3.15 Average channel cladding temperatures vs. time at axial level 11	52
3.16 Averaged channel cladding temperatures vs. time at axial level 21	53
3.17 Averaged channel cladding temperatures vs. time at axial level 28	54
3.18 Averaged channel cladding temperatures vs. time at axial level 39	55
3.19 Axial cladding temperature distribution in the hot channel compared	57
3.19 Axial cladding temperature distribution in the hot channel compared	58
3.20 Calculated void fraction, flow regime and HTC (nodalization 6-00)	60
3.21 Calculated void fraction, flow regime and HTC (nodalization 6-01)	61
3.22 Calculated void fraction, flow regime and HTC (nodalization 8-10)	62
3.23 Calculated void fraction, flow regime and HTC (nodalization 8-03)	63
3.24 Calculated void fraction, flow regime and HTC (nodalization 6-00)	64
3.25 Calculated void fraction, flow regime and HTC (nodalization 6-01)	65

3.26 Calculated void fraction, flow regime and HTC (nodalization 8-10)	66
3.27 Calculated void fraction, flow regime and HTC (nodalization 8-03)	67
3.28 Fuel center temperature in the hot channel at level-27 compared	70
3.29 Fuel center temperature in the hot channel at level-43.8 compared	71
3.30 System pressures in the cold leg vs. time compared with pressure	72
3.31 Pressures in the pressurizer vs. time compared with pressure	74
3.32 Downcomer fluid temperatures vs. time compared with	75
3.33 Mass fluxes into the hot channel of the core as calculated	77
3.34 Mass fluxes out of the hot channel of the core as calculated	78
3.35 Momentum fluxes into the hot channel of the core as calculated	79
3.36 Momentum fluxes out of the hot channel of the core as calculated	80
3.37 Core averaged liquid fractions vs. time as calculated by RELAP5/Mod2	82
3.38 Calculated mass flows out of the broken cold leg vs. time	83
3.39 Calculated mass flows out of the broken hot leg vs. time	84
3.40 Calculated mass losses out of the double ended break vs. time	86
3.41 Calculated mass flows in the intact hot leg vs. time	87
3.42 Calculated mass flows in the intact cold leg vs. time	88
3.43 Calculated relative pump speed vs. time compared with	90
3.44 Calculated accumulator fluid levels vs. time compared with	92
3.45 Calculated accumulator pressure vs. time compared with	93
3.46 Calculated accumulator mass flows vs. time compared with	94
3.47 Calculated LPIS discharges vs. time compared with the measurement	95
3.48 Comparison of cladding temperatures calculated by RELAP5/Mod2	98
3.48 Comparison of cladding temperatures calculated by RELAP5/Mod2	99
3.48 Comparison of cladding temperatures calculated by RELAP5/Mod2	100
3.48 Comparison of cladding temperatures calculated by RELAP5/Mod2	101
3.48 Comparison of cladding temperatures calculated by RELAP5/Mod2	102
3.49 Comparison of cladding temperatures calculated by RELAP5/Mod2	103
3.49 Comparison of cladding temperatures calculated by RELAP5/Mod2	104

List of Tables

1.1	Initial Conditions for LOFT-experiment LP-LB-1	7
2.1	Numbers of volumes, junctions, heat-structures and fine-meshes as well	18
3.1	RTM values in different intervals of the transient	24
3.2	Comparison of characteristic parameters inferred from experiment	30
3.2	... cont.	31
3.2	... cont.	32
3.2	... cont.	33
3.2	... cont.	34
3.2	... cont.	35
3.2	... cont.	36

Chapter 1

Introduction

1.1 Short Description of the LOFT Experiment LP-LB-1

The LOFT facility at Idaho National Engineering Laboratory was designed to simulate the major components and system responses of a commercial PWR during a LOCA for the determination of system transient characteristics and for the assessment of code predictive capabilities for design basis large- and small break LOCAs in pressurized water reactors. The experimental assembly includes five major subsystems which have been instrumented such that system variables can be measured and recorded during LOCA simulation. The subsystems include the reactor vessel, the intact and the broken loop, the blowdown suppression system and the ECC systems; the arrangement of these major components is shown in Fig. 1.1. The entire nuclear core consists of five square and four triangular fuel bundles with a total of 1300 fuel pins each of 1.67m long and an outside diameter of 10.72 mm. A complete system description is given in ref.[1] and a discussion of the LOFT scaling philosophy is provided in ref.[2].

Experiment LP-LB-1 was conducted on February 3, 1984, in the Loss-Of-Fluid Test (LOFT) facility at the Idaho National Engineering Laboratory. It was the second large-

break loss-of-coolant accident (LOCA) simulation and the fifth experiment at all conducted in the LOFT facility under the auspices of the OECD. This experiment simulated a double-ended off-set shear of one inlet pipe in a four loop PWR. The experiment was initiated from conditions representative of PWR licensing limits and simulated a loss of offsite power coincident with a large leg break LOCA. The boundary conditions included minimum UK safeguard assumptions for emergency core coolant injection (no HPIS) and rapid primary coolant pump coast-down. In addition, a loss of off-site power has been assumed.

The initial conditions for experiment LP-LB-1 have listed in table 1.

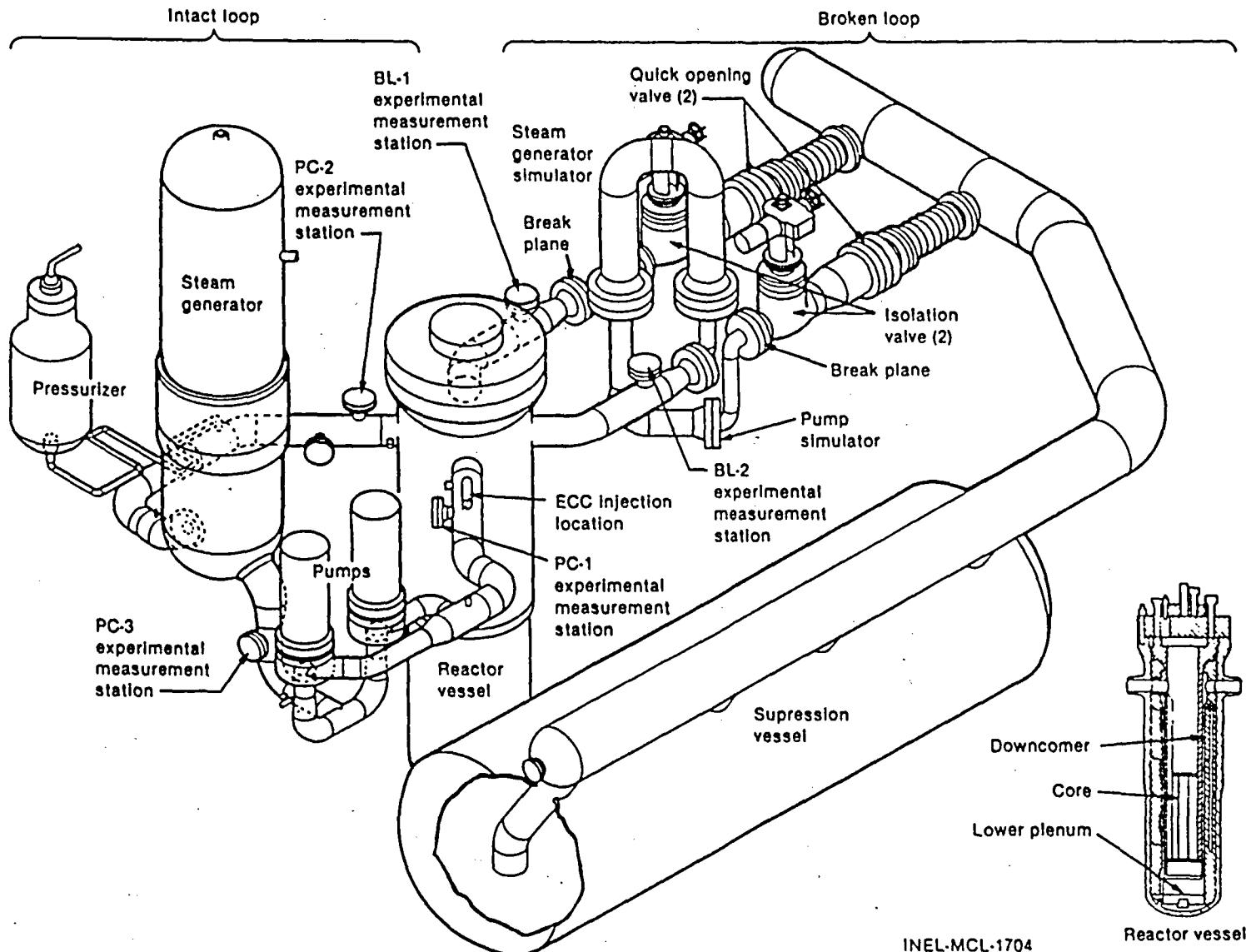
The transient was initiated by opening the quick-opening blowdown valves in broken loop hot and cold legs. Pressure decreased rapidly due to the blowdown, with saturated conditions being reached in the upper plenum at 0.04 seconds.

The reactor scrammed automatically when the intact loop hot leg pressure dropped to 14.5 MPa at 0.1 seconds.

The primary coolant pumps were tripped manually and decoupled from their flywheels within one second, effecting a rapid coast-down.

The core flow stagnated immediately af-

Figure 1.1: LOFT components showing thermo-fluid instrumentation



Initial Conditions for experiment LP-LB-1		
parameter	unit	measured value
power	MW	49.3 ± 1.2
maximum linear heat	kW/m	51.7 ± 3.6
ΔT_{core}	K	29.8 ± 1.4
pressure _{hot leg}	MPa	14.9 ± 0.08
mass flow rate	kg/s	305.9 ± 2.6
fluid temperature _{cold leg,intact loop}	K	556.0 ± 1.0
fluid temperature _{cold leg,broken loop}	K	552.0 ± 6.0
fluid temperature _{cold leg,broken loop}	K	561.0 ± 6.0
pressurizer :		
liquid level	m	1.04 ± 0.04
pressure	MPa	14.9 ± 0.11
water temperature	K	615.0 ± 5.8
ECC system accumulator :		
liquid level	m	2.36 ± 0.01
standpipe position from bottom	m	2.11 ± 0.03
pressure	MPa	4.21 ± 0.06
liquid temperature	K	302.0 ± 6.1
ECC system LPIS :		
liquid temperature	K	305.0 ± 7.0
flow rate	l/s	depending on pressure difference between LPIS and downcomer

Table 1.1: Initial Conditions for LOFT-experiment LP-LB-1

ter the initiation of the transient and fuel rod cladding temperatures started to increase. All fuel rods in the central fuel assembly (box 5) experienced temperatures in excess of 1100 K in their high power regions (about 24 inches from the bottom of the core), whereas the maximum cladding temperatures reached peak values of 1261 K during blowdown and 1257 K during refill/reflood which were the highest temperatures ever measured in LOFT. The core-wide temperature increase continued until a partial core top-down quench occurred, starting at 13 seconds, which affected the top third of the core. It is assumed that this top-down quench was caused by liquid fallback from the upper plenum induced by gravity. After this, the fuel rod cladding again experienced departure from nucleate boiling. There were additional thermal cycles prior to the final core quench, which was complete at 72 seconds. For more details see ref. [3].

One of the major concerns with Experiment LP-LB-1 was whether fuel rod damage would occur. Based on the indicated cladding temperatures, the pressure differential across the cladding and the evidence from isotope detection systems, no fuel rod ballooning or cladding rupture occurred.

A comparison of results of Experiment LP-LB-1 with previous LOFT large break LOCA experiments e.g. L2-3, L2-5 and LP-02-6 (the first with continuous pump operation, the last two with pumps disconnected from their flywheels) shows significant differences in the primary system thermal hydraulic responses, specifically partial core top-down quench depressurization during blowdown. These differences are believed to be largely due to differences in the primary coolant pump operation, and, to a lesser extend, in ECC injection and initial core power. Because of these significant thermal hydraulic

behaviour, experiment LP-LB-1 seems to be very useful for testing the predicting capabilities of a best-estimate code like RELAP5/Mod2.

1.2 The Aim of the Present Investigations

Codes like RELAP5/Mod2 and TRAC have been often used for the analysis of LOFT experiments and LOFT results have been extensively used to eliminate insufficiencies both in the codes themselves and the more plant-specific nodalization of the problem by comparing the predictions of the code with the real measurements. Therefore, one has to be aware of the fact that both the code and the LOFT-specific nodalization, normally used for pre- and post-test analyses, are somehow "LOFT-tuned" resulting in quite acceptable predicting capabilities.

Of course, the genuine field of application for best estimate codes is believed not to be the analysis of LOFT experiments but the prediction of the behaviour of commercial LWR's, where they should predict accurately if the system remains always in safe conditions. To be sure of the code's predicting capability of abnormal situations in real power plants, two main conditions have to be fulfilled :

- the different models of the code have to be adequate for the problem
- the plant has to be nodalized adequately, such that main expected phenomena are simulated

For the verification and possibly also for the optimization of the different models of the code, comparisons of the results of "integral test" like LOFT may be not an appropriate

choice because possible deviations cannot be simply attributed to a specific model. Here, one should prefer the comparison with the results of "separate effect tests".

For the plant to be analysed an "adequate nodalization" is usually unknown and only some very rough criteria can be given to the code user. Consequently, the accuracy of a prediction may be strongly related to the "experience" of the user, a quite unsatisfactory conclusion.

To get a feeling, how the nodalization may influence the prediction of the code, experiment LP-LB-1 has been analysed with respect to the following questions :

- The general predicting capability of the code, i.e. how accurate the sequence of events of experiment LP-LB-1 is calculated by RELAP5/Mod2 cy36-02 in time and value, especially, if the code is able to predict the phenomena of top-down quenching during the blow-down phase of the experiment which in the upper third of the core has some influence on the peak cladding temperatures.
- The influence of the nodalization (number of volumes, junctions and heat structures which describe the whole system) on the calculation, i.e. how the nodalization may influence the accuracy of the results obtained.

Therefore, in what follows, we shall analyse the LP-LB-1 experiment by using the best estimate code RELAP5/Mod2 cy36-02 with different nodalizations of the LOFT system. Starting with a nodalization similar to the one used by the code developers at INEL (especially for the analysis of small break LOCAs) we shall reduce the number of volumes, junctions and heat structures in the primary loop of the LOFT system to nearly

half whereas the entire vessel stays nearly unchanged to meet the requirements of the given experimental axial positions in the core region, especially for the cladding temperature measurements. We shall further investigate on the influence of the fine-meshing in the core zone during reflooding on quench time and quench temperature.

Finally, we shall see, how the reduction of volumes and junctions will influence the computer time, needed to analyse the experiment, a question which is important from the financial point of view. On the other hand, in the framework of this contribution, no attempts will be made to improve models within the code.

Chapter 2

Nodalization Schemes Used to Analyse Experiment LP-LB-1

The basis of all schemes of nodalization normally used for LOFT analyses are those developed at INEL for the RELAP5/Mod1 calculations of the small break experiments LP-SB-1 to LP-SB-3. Similar schemes have been applied for the analyses of experiment LP-SB-3 by Andreani and Grütter, ref. [4], as well as for all of the other LOFT post-test analyses initiated by the OECD-LOFT- Consortium and using RELAP5/Mod1 or -Mod2 codes.

This basic INEL LOFT nodalization scheme for the RELAP5/Mod1 as well as the -Mod2 code is divided in seven main parts which may be distinguished by their "capital component" numbers :

- (1...) Intact Loop
- (2...) Reactor Vessel
- (3...) Broken Loop
- (4...) Pressurizer
- (5...) Steam generator,
secondary side
- (6...) ECC system
- (7...) Containment
(suppression tank)

The ECC systems, the containment and the reactor vessel remained quite unchanged for the different nodalizations discussed in

due course, whereas the steam generator primary and secondary sides, the pressurizer as well as intact and broken loops have been undergone drastic reductions with respect to the initial number of volumes and junctions resulting in reduced computer time and simplification of the problem.

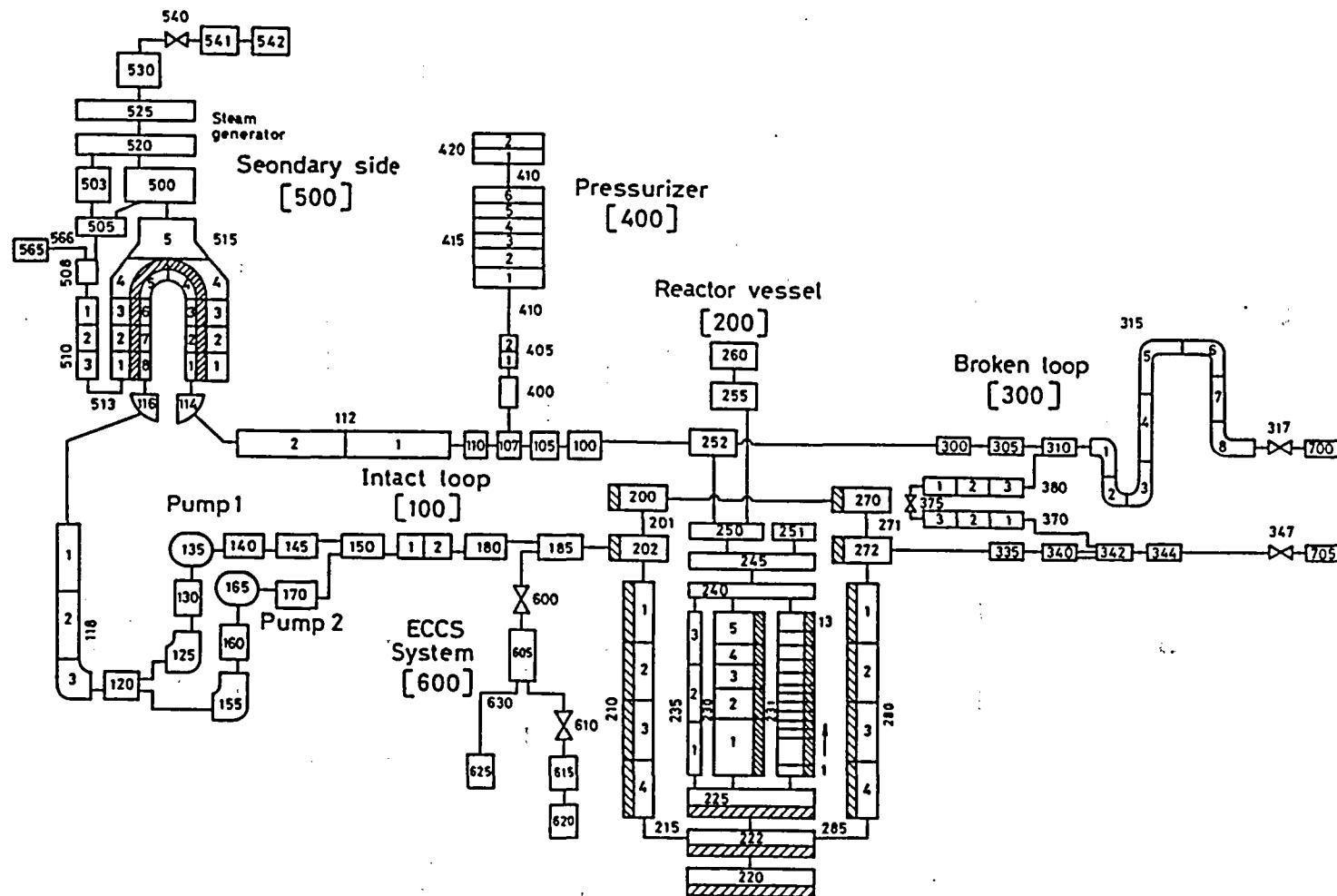
2.1 Standard Nodalization

Let us start with the "standard nodalization" (later on marked by 6-00...) which, compared to the above mentioned INEL-schemes, only has slightly modified to better meet the requirements of the large break experiment LP-LB-1 , especially in the core region (Fig. 2.1).

The REACTOR VESSEL consists of the reactor core, of the intact and broken loops downcomer sections (volumes 200 to 210 and 270 to 280 respectively), the lower plenum (220 to 225) and the upper plenum with the vessel dome (240 to 260).

The REACTOR CORE itself has been modeled by three parallel channels, the average channel (230) subdivided into 5 hydrodynamic volumes, the hot channel (231) subdivided into 13 volumes and the bypass

Figure 2.1: Nodalization 6-00/6-01 of the LOFT system (most detailed version; similar to EG&G nodalization)



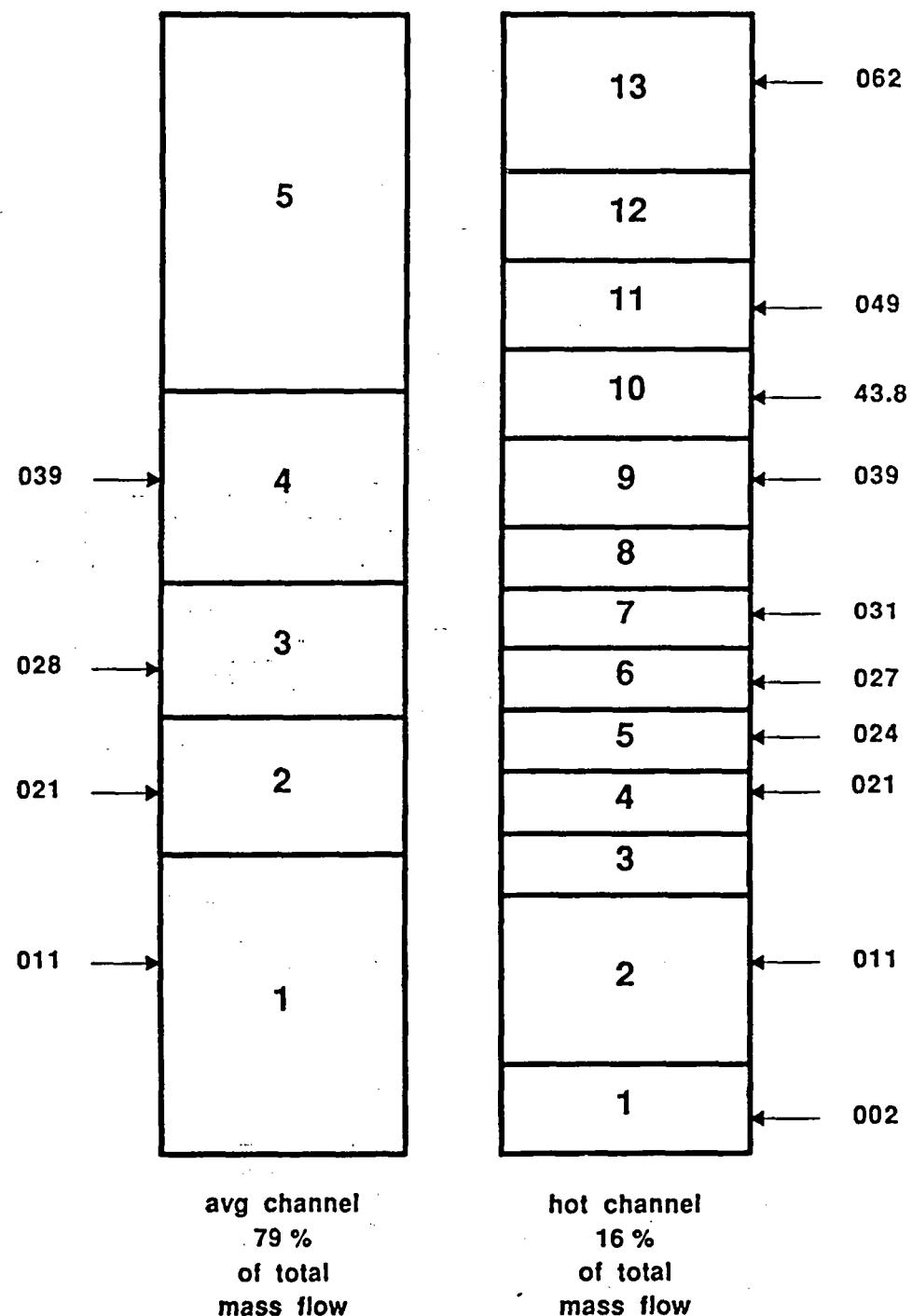


Figure 2.2: Detail of the nodalization of the LOFT core
(average and hot channels)

channel (235) into three equally spaced volumes. In Fig. 2.2, a separate scheme illustrating the nodalization of the active core has been given. Here, the hydrodynamic volumes are not equally sized and they were dimensioned so that the "reference thermocouple location" (cladding temperature measurement indicated by arrows) are always located nearly in the axial center of the requested volume.

The hot channel represents the center part of the core (mainly fuel-assembly 5) and contains 219 pins, the remaining 1081 pins are assigned to the average channel. The axial linear heat flux distribution was chosen according to ref. [5].

The total mass-flow through the core is shared approximately 79% by the average channel, 16% by the hot channel and the remaining 5% by the bypass. Note that the mass-flow distribution in the core region is somehow arbitrary. The choice of these values is based on the relation of the pin numbers associated with each of the channels (arbitrary!) minus the bypass flow which is again an estimated parameter. No crossflow has been assumed between the three channels, because preliminary runs using junction elements between the different nodes of the two heated channels had shown that the amount of mass exchange in traverse direction remained negligible during the whole transient.

The fuel pins have been modeled by heat structures each radially meshed into 5 (average channel) and 10 nodes (hot channel) respectively. In the "average pin", one zone represents the cladding, one the gap and two the fuel. For the "hot channel", there are 3 cladding zones, one gap and 5 fuel zones. In case of reflooding, the code performs an axial finemeshing for better modelling the advancement of the quench front. The maximum

number of allowable fine meshes has to be preset. The influence of two different presets has been investigated namely 4 (avg.) and 2 (hot) as a minimum (nodalization 6-00) and 64 (avg.) and 32 (hot) as a maximum value (nodalization 6-01).

The INTACT LOOP consists of 20 volumes with 2 or 3 subvolumes. As in the actual LOFT system, the pumping system is divided into two pump lines with two individual pumps numbered 135 and 165 respectively. The ECC-injection system consisting of a Low Pressure Injection System (LPIS) and an accumulator is connected to the cold leg of the intact loop (volume 185). In addition to the usual ECC line valve (600), a supplementary control valve (610) has been inserted in the accumulator line to close this line when the accumulator is empty. This happens to be necessary in order to continue with the calculation. Probably due to the fact that the version RELAP5/Mod2 cy36-02 used for these calculations was not able to handle noncondensables, the transient always was terminated by an execution error when the accumulator was just emptied and nitrogen was released into the system.

The STEAM GENERATOR consists of 8 volumes on the primary and 5 volumes on the secondary side. A simplified feed, backflow and steam separator modeling as well as a steam flow control valve and condensator unit complete the nodalization of the secondary side. The steam flow valve is controlled by a control logic which allows to keep the secondary side pressure constant. Heat is exchanged from the primary to the secondary side of the steam generator via the wall which is modeled by 8 heat structures each having 7 radial zones (8 nodes).

The PRESSURIZER is composed of the surge line (2 volumes) and the entire pressurizer. The latter is nodalised by a pipe com-

ponent (6 subvolumes) which represents the main vessel, and another pipe (2 subvolumes) which describes the pressurizer dome.

The BROKEN LOOP consists of two individual lines. The hot line has been nodalised by 3 volumes (300 to 310) and one pipe component (315), representing the steam generator simulator. The cold line is consisting of 4 volumes (335-344). At the end of each of the lines, the two break-valves which have to be opened by a trigger signal are placed and connected with the suppression tank, modeled here by two time-dependent volumes (pressure is a function of time). In addition, for preheating the broken loop, a bypass line exists between volumes 310 and 342. This bypass line has been nodalized by two pipe components. In our calculations, the connecting valve (375) remained always closed.

Not included in Fig. 2.1 are some additional control-valves and heat structures, especially for the pressurizer which are only necessary for steady-state runs to force the system to a stable stationary solution at the desired thermal conditions like circulation mass-flow, core-inlet and core-outlet fluid temperatures, liquid level in the pressurizer, etc.

Because of the rather fast transient of a large break LOCA (the total duration of the transient is about 100 seconds), heat capacity effects of the piping walls, vessel walls and other structures in thermal contact with the coolant, may not play an important role. Consequently, for the sake of saving computer time, in the normal versions of nodalization, heat structures were used only for modeling the heat generation in the reactor core and for the heat transfer from the primary to the secondary side of the steam generator. For some runs, the influence of the heat capacity of the

reactor vessel on the transient behaviour of the thermal-hydraulic parameters of interest has been investigated and therefore, some additional heat structures have been inserted in the downcomer and the lower plenum of the reactor vessel (heat-structures 200-210, 220, 222, 225 and 270-280); these runs are marked by an additional "C" to the nodalization number (e.g. 6-00C).

2.2 Stripped Nodalisations

To investigate the influence of reduced number of volumes and junctions on the accuracy of the analysis as well as on a probable saving of computer time, the number of junctions and volumes of the standard nodalization has been drastically reduced.

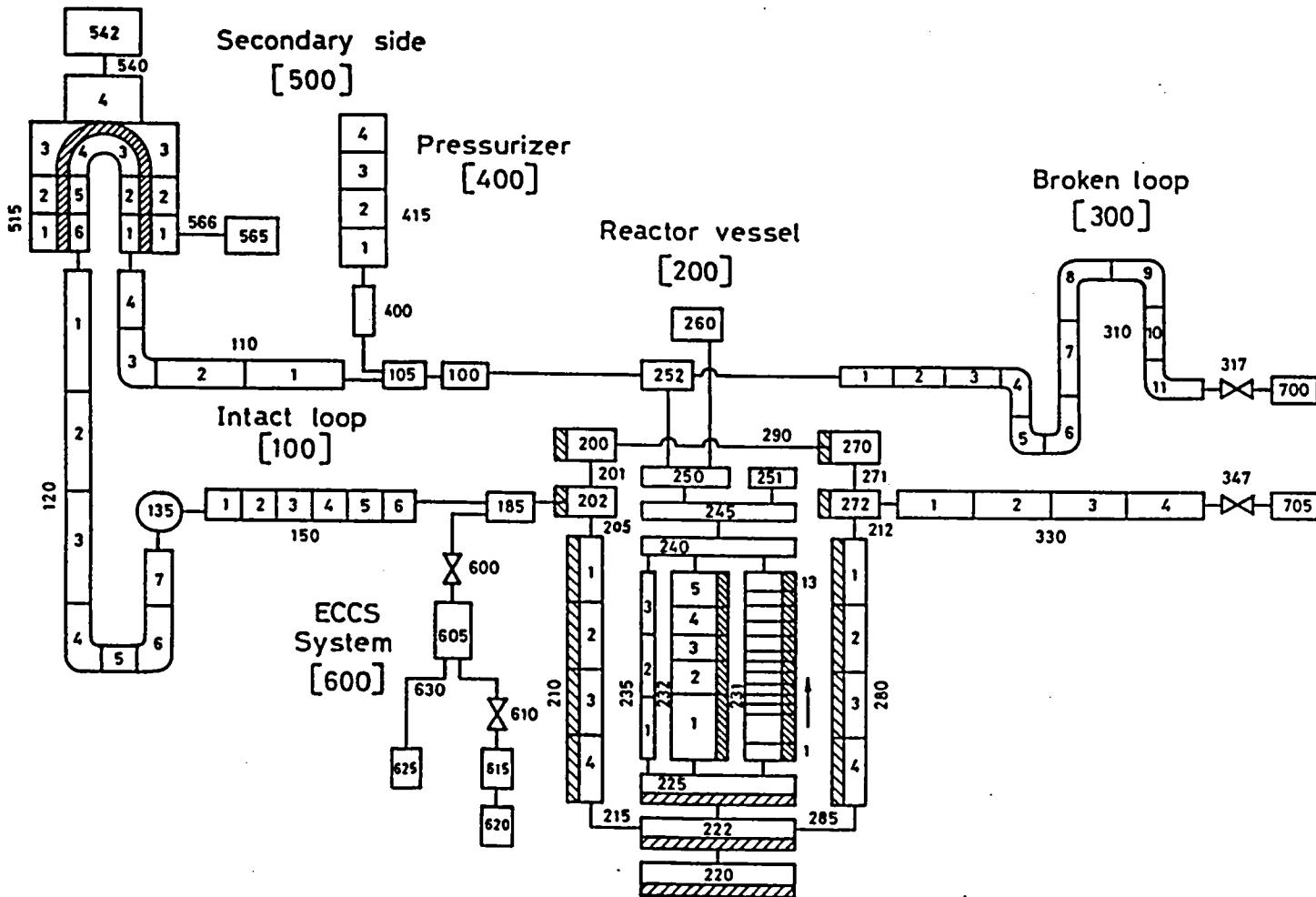
A scheme of the first stripped version, the nodalization 8-00, is shown in Fig. 2.3. The main changes have been made in the pressurizer, the intact- as well as in the broken loops and on the secondary side of the steam generator, whereas the REACTOR VESSEL and the ECC-system remained nearly unchanged.

The INTACT LOOP now mainly consists of three pipe sections (110, 120 and 150 with four, seven and six subvolumes respectively), only one pump component instead of two (but of course, with the same pump-head) and a steam generator primary side with six instead of the previous 8 subvolumes.

The BROKEN LOOP consists of only two pipe systems (310 and 330) with 11 and 4 subvolumes respectively. Since the bypass-valve (see component 375 in Fig.2.1) is always closed, in this stripped version of nodalization, the whole bypass-line has been omitted. Consequently, possible mass and heat capacity effects in this line are neglected.

The whole PRESSURIZER system (vessel

Figure 2.3: Nodalization 8-00 / 8-10 of the LOFT-system
 (simplified nodalization; core remained unchanged)



and surge-line) has been reduced to one pipe component with four subvolumes only.

The SECONDARY SIDE of the steam generator and the attributed system has been undergone drastic reductions. In principle, the steam generator has been turned into a simple heat exchanger with single-phase flow on the secondary side. The flow is simply controlled by a time-dependent junction (566) and dumped into an outlet volume (542). To maintain correct primary side inlet and outlet conditions, the mass flow has been adjusted to quite higher values than for the real steam generator conditions where the evaporation of the water is the main heat sink. The wall between the primary and secondary side of the steam generator has been modeled by six heat structures each radially divided by three zones.

Nodalization 8-10 is identical to 8-00 with respect to the number of volumes, junctions and heat structures but differs in modeling the nuclear fuel rods by reducing the number of radial meshes of the heat structures in the core zone from 10 to 5 in the hot channel (one zone for the cladding, one for the gap and two for the fuel) and from 5 to 4 in the average channel (one zone for the cladding, one for the gap and one for the fuel). Fine-meshing remains at 2 (hot) and 4 (avg.).

The reduced nodalization 8-00 can be stripped even more by simply reducing the subvolumes of each of the pipe components; for the pipe 110 to two, for pipe 120 and 310 to three and for pipe 150 and 330 to only one subvolume each. The nodalization of the steam generator has been reduced to only two on both sides but the radial meshing of the related heat structures remained at three nodes (fig. 2.4).

The maximum number of fine meshes of the

heat structures of the core during reflooding remains at two in the hot and at four in the average channels. This very much reduced nodalization is called 8-03.

All the stripped versions have been used with and without heat capacity contribution in the vessel component, as described above.

Finally, in table 2.1, characteristic parameters of the different nodalizations (e.g. number of volumes, junctions and heatstructures, mass inventory of primary and secondary sides as well as the corresponding system volumes) used for this study have been listed. Included in table 2.1 are the average "Real-Time-Multipliers" RTM0 which are the quotient of the CPU time (on a CYBER-855 machine) divided by the duration of the analyzed transient; the RTM0 should illuminate the effect of nodalization from the economical point of view.

Figure 2.4: Nodalization 8-03 of the LOFT system (most simplified version; core remained unchanged)

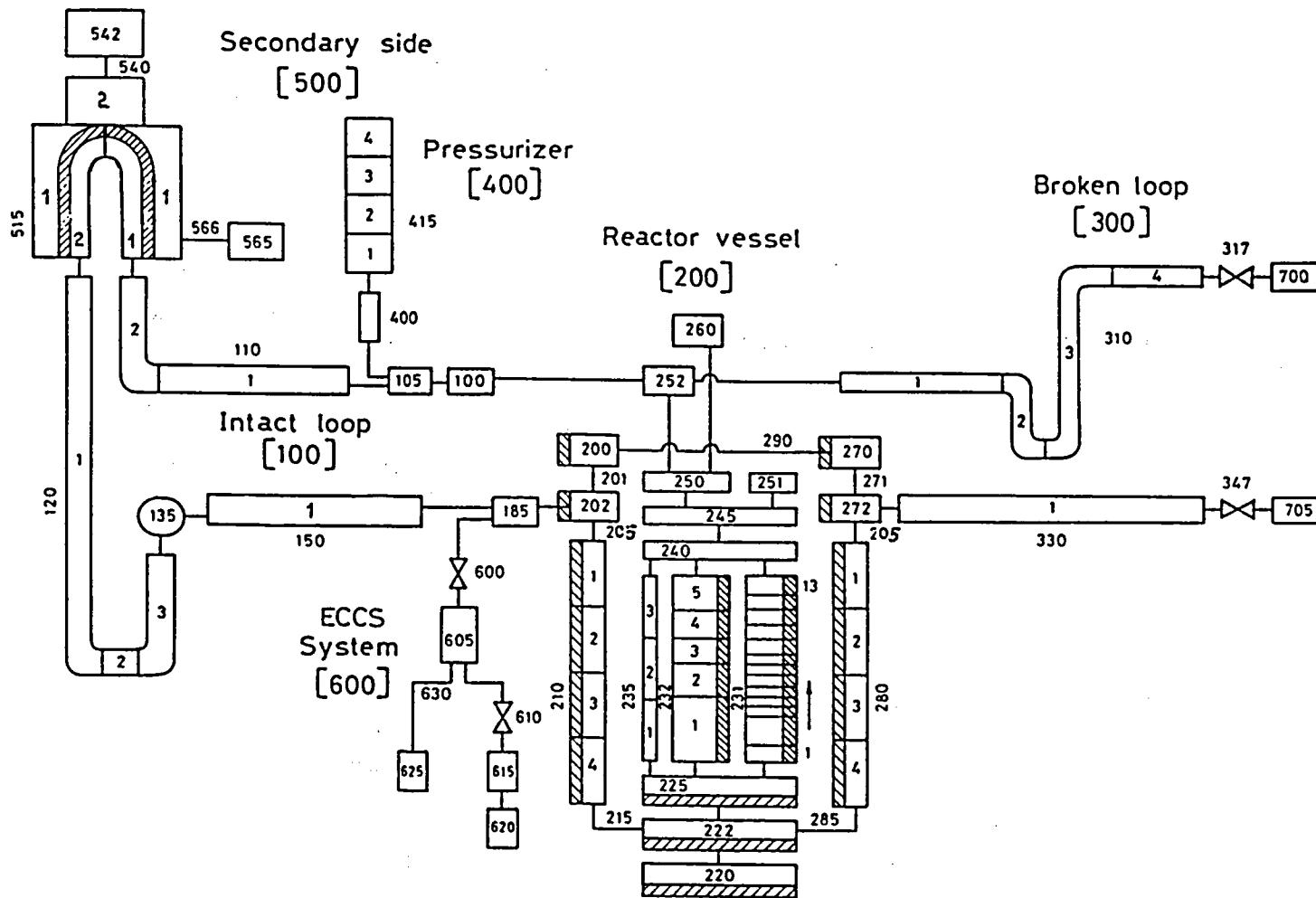


Table 2.1: Numbers of volumes, junctions, heat-structures and fine-meshes as well as the resulting Real-Time-Multiplier RTM

NAME	HYDRODYNAMICS				HEAT STRUCTURES		RTM0
	number of volum.	number of junct.	primary side mass to	volume m^3	secondary side mass to	volume m^3	
6-00	133	139	6.8	9.9	2.3	11.4	26/219 4/2 31.9
6-00C	133	139	6.8	9.9	2.3	11.4	41/294 4/2 32.6
6-01 ¹	133	139	6.8	9.9	2.3	11.4	26/219 64/32 43.4
6-01C	133	139	6.8	9.9	2.3	11.4	41/294 64/32 41.8
8-00 ²	101	103	6.6	9.6	1.6	1.9	24/173 4/2 35.1
8-00C	101	103	6.6	9.6	1.6	1.9	39/248 4/2 28.1
8-10 ³	101	103	6.6	9.6	1.6	1.9	24/103 4/2 32.5
8-10C	101	103	6.6	9.6	1.6	1.9	39/178 4/2 29.8
8-03 ⁴	74	76	6.6	9.6	1.6	1.9	20/161 4/2 24.2
8-03C	74	76	6.6	9.6	1.6	1.9	35/236 4/2 20.5

⁰ $RTM0 = [CPU(t_{end}) - CPU(t_{begin})]/[t_{end} - t_{begin}]$

¹Fine meshes for reflooding increased from 4/2 to 64/32

²Reduced number of volumes in intact loop, broken loop and pressurizer

³Same as 8-00 but with less radial meshes in the fuel rod modelling

⁴Same as 8-00 but with even more reduced numbers of volumes and junctions in the intact and broken loops

Chapter 3

Results

Starting from thermal-hydraulic conditions very close to the ones given in table 2.1, total of ten calculations of the LOFT-experiment LP-LB-1 each lasting 120 seconds have been performed using the code RELAP5/Mod2 , cy36-02 and the different nodalization schemes described in chapter 2.

In our understanding, with respect to reactor safety one set of "key-parameters" of a large break calculation are mainly the time behaviours of the cladding temperatures at different axial positions (peak temperature, as well as the duration of being over a certain temperature level, which may cause partial zircaloy- water reaction) and with minor importance the peak fuel temperatures. Because the reactor was scrammed after a very short time from the initiation of the experiment, the center fuel temperatures seldom exceed the values of normal operation at full power. Consequently, we shall focus on the time behaviour of the cladding temperatures. But even a satisfactory agreement between the experimental and the calculated cladding temperatures or between other significant parameters of the experiment like pressures, densities or mass-flows should not automatically lead to the conclusion that the code predictions are accurate and RELAP5/Mod2 perfectly has done its job. Because one may argue that the code has given "right answer for the wrong rea-

sons", i.e. a satisfactory calculation of the time behaviour of the cladding temperatures could be the result of an "optimized summation" of individual errors. Therefore, one has to look carefully if the code has accurately described the main phenomena occurring during the experiment. Consequently, one has to investigate in detail the time traces of the other thermal-hydraulic parameters of importance as well.

In what follows, we would like to start with some words on the updating of the experimental data especially on the averaging process of some temperature traces and of the power (neutron flux data).

The discussion of the results of the calculations we shall start by looking at the influence of the nodalizations on computer time and mass errors.

Second, we shall discuss the capability of RELAP5/Mod2 to predict significant events of the experiment like peak cladding temperatures (value and time of their occurrence), the time when pressurizer and accumulator empties as well as the positions of the quench front during the reflood period of the experiment.

Third, we shall analyse additional thermal-hydraulic parameters of the LOFT-plant as given by RELAP5/Mod2 , starting with

the time behaviour of our "key parameters" (cladding and center fuel temperatures) and we shall compare these results with the corresponding data of Experiment LP-LB-1 , if available.

Finally, in a separate chapter, we shall investigate in the ability of the code to predict top-down rewetting, a phenomenon which has occurred in LP-LB-1 during 15 and 20 seconds after the initiation of the experiment.

3.1 Experimental Results

The experimental results have been retrieved from the LOFT-transmittal tape. For most of the experimental values only one set of data is available except for the temperature data of the core region and a few other variables.

The uncertainty of most of the experimental data can be found in table VI of the "Transmittal Tape Description" (ref. [8]). We have used the values listed there for giving the respective uncertainty of the "reference" on each individual plot, if possible.

Difficulties may occur in using the cladding temperature traces at the different core heights of the "hot bundle" 5, only when these values are averaged. In Figs. 3.1a and 3.1d, the temperature traces of all the available thermocouple signals radially distributed in the center box (box 5) at one specific core level have been plotted at four different levels, namely at level 24 (24 inches from the bottom of the core), at level 31, at level 43.8 and at level 49. We have selected the first two examples because at level 24, the highest surface temperatures have been measured during the experiment, whereas the code predicted the highest temperatures at level 31. The last two levels have been selected because top-down rewetting, one of the key events of experiment LP-LB-1 , mainly

took place in this upper third of the core.

In Fig. 3.1a, the traces of all the available six thermocouple signals radially distributed in the center box (box 5) at core level 24 have been plotted. Whereas two of them behave quite similar (the deviation of the cladding temperatures never exceeds 30 K), the other four have remained at operational temperatures during the whole blow-down phase and started heating up 25 seconds after the initiation of the experiment. This behaviour certainly would lead to a much lower "average temperature" especially during the blow-down phase of the experiment. Therefore, when computing the "reference temperature", we have omitted these four signals; the resulting reference temperature is indicated by squares. Nevertheless, this "manipulation" of the reference temperature may be regarded as to be somehow dubious.

In Fig. 3.1b, the time behaviour of all the available 14 thermocouple signals at core level 31 have been plotted. One of the 14 thermocouples has undergone a significant temperature drop followed by a heat-up for which reason we can only speculate. Because its uniqueness, this thermocouple has not been used to form the "reference temperature", again indicated in fig. 3.1b by symbols.

At core level 43.8, a total of 13 thermocouples radially distributed in the center box (box 5) are available. Only four of these 13 thermocouples have undergone a significant top-down quench whereas the others nearly remained on their high temperature level. Because top-down rewetting has been regarded as one of the key events of experiment LP-LB-1 , all thermocouples have been used to form the "reference temperature; top-down rewetting is clearly indicated in the reference (fig. 3.1c).

Finally, at level 49, both of the two available thermocouple signals experienced top-

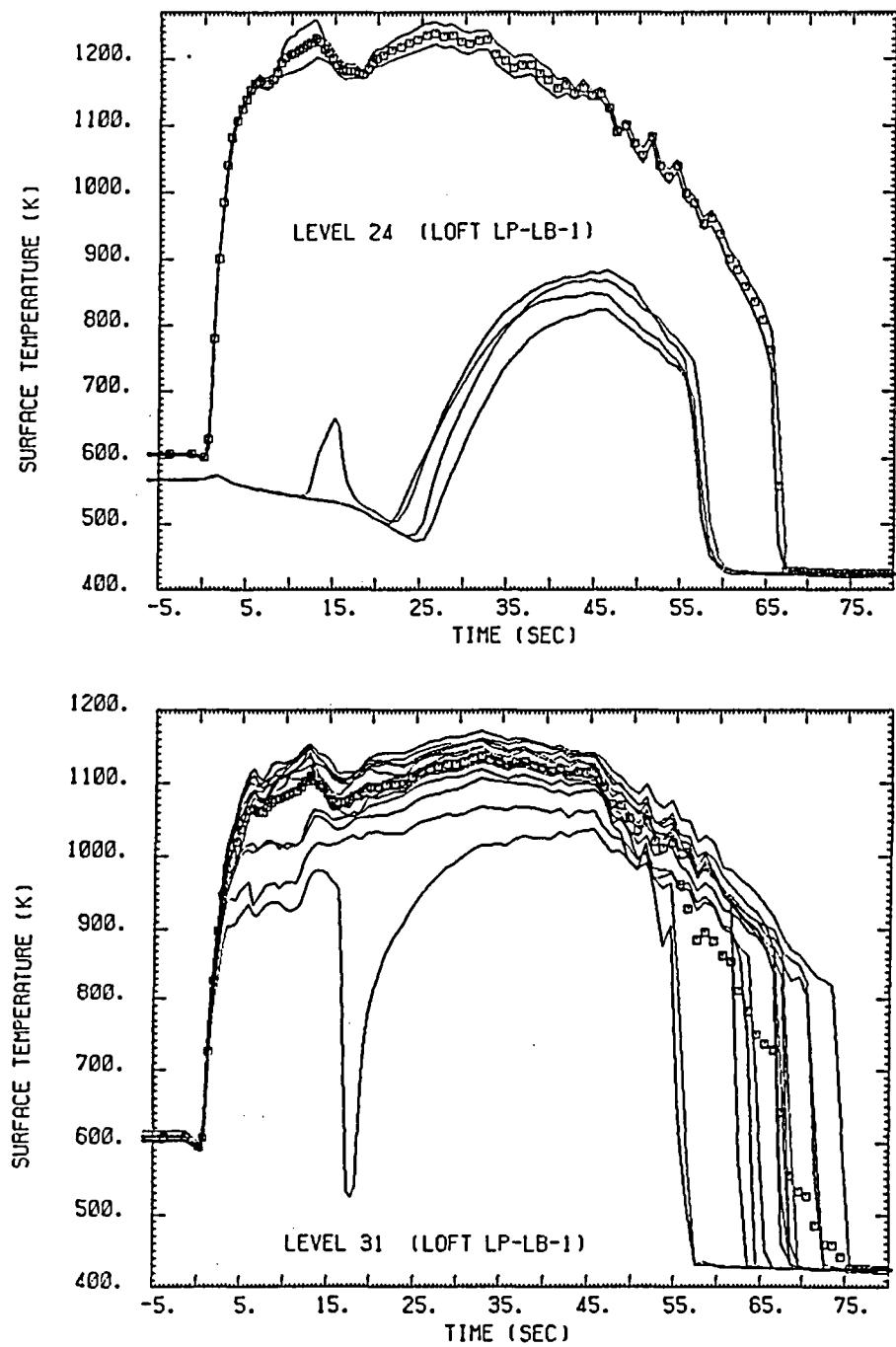


Figure 3.1: Measured cladding temperatures in center bundle 5
(averaged values (symbols) used as reference)
a.) at axial level 24
b.) at axial level 31

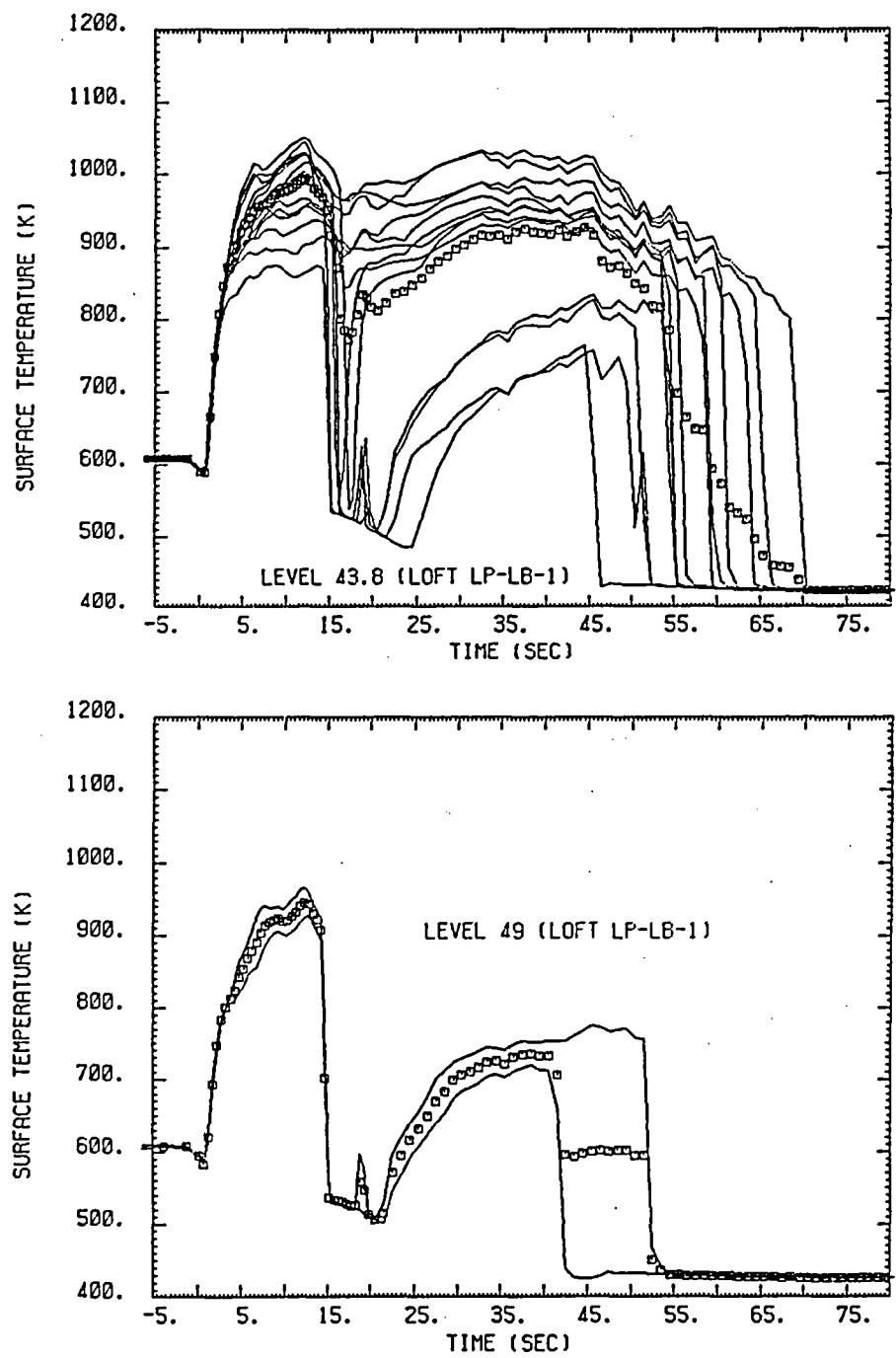


Figure 3.1: Measured cladding temperatures in center bundle 5
(averaged values (symbols) used as reference)
c.) at axial level 43.8
d.) at axial level 49

down rewetting at approximately 15 seconds after the initiation of the experiment. The average of the two signals has been used as "reference temperature".

Because the different, radially distributed thermocouples at one specific level have quenched at not exactly the same time, the "one dimensional quench front position" as calculated by RELAP5/Mod2 has to be compared to a slightly uncertain reference which varies between least 10 and 20 seconds.

In addition to the problem of averaging, the uncertainty of the temperature measurement itself is not fully established yet. Because the thermocouples of the LOFT facility were surface mounted ones, there are still some doubts whether these thermocouples always measure the temperature of the surrounding cladding material or e.g. did not have quenched in advance by impinging water droplets (ref. [9]).

3.2 Influence of the Nodalization on Computer Time and Mass Error

Starting with the influence of the nodalization on the computer time and disregarding the accuracy of the predictions themselves for the present, a first look to the RTM0s in table 2.1 will lead to the conclusion that a severe reduction of the number of volumes and junctions will not lead automatically to a significant decrease of the computer time consumption, as can be seen with the cases 6-00 and 8-00 where the much reduced version 8-00 runs slightly slower. Nevertheless, in general a reduction of the number of volumes, junctions and radial meshes as well as fine-meshes has lead to more economic calculations.

A more detailed analysis of the computer

time needed to analyse the LOFT experiment LP-LB-1 is shown in table 3.1. Here, the transient times have been subdivided into nine time intervals, the stationary part from -10 to zero seconds, the initial blowdown part (zero to 2 s) three entire blowdown parts (2 to 8 s), (8 to 15 s) and (15 to 25 s), two reflood intervals (25 to 50 s) and (50 to 70 s) with the starting sequence of the Emergency Core Cooling System (ECCS) during the first of these intervals (i.e. the feed of cold water out of the accumulator and the Low Pressure Injection System (LPIS) into the saturated fluid of the intact loop) and finally two more stationary intervals (70 to 85) and (85 to 120 s).

The reduction of the computer time due to a reduction of volumes, junctions and heat structures became mostly significant within the first and the last time intervals, i.e. in the more or less stationary part of the transient; in addition, also the interval immediately after the opening of the break where the scram of the reactor has taken place is characterized by a rather low consumption of computer time.

The relatively low RTM-values during the more or less stationary parts of the transient have been somehow compensated during the third blowdown (15 to 25s) and especially during the first reflood interval (25 to 50 s) where large number of numerical instabilities occurred due to a great degree of thermodynamic non-equilibrium in the intact cold leg and downcomer region mainly caused by the injection of cold water of the ECC system into the saturated fluid inside the intact cold leg.

A visualization of the table 3.1 has been presented in figs. 3.2a and 3.2b where the RTM-values for the different nodalizations have been plotted versus the experimental time.

In Fig. 3.2a, the RTM values are shown for

$$RTM_{interval} = [CPU(t_2) - CPU(t_1)]/[t_2 - t_1] \quad (\text{computer : CYBER-855})$$

Table 3.1: RTM values in different intervals of the transient

Time interval			Nodalisation									
			6-00	6-00C	6-01	6-01C	8-00	8-00C	8-10	8-10C	8-03	8-03C
-10	-	0	17.1	17.6	17.4	17.5	12.4	13.3	12.3	12.9	9.6	10.1
0	-	2	13.3	13.9	13.6	13.8	9.7	10.5	10.0	10.5	6.2	5.3
2	-	8	23.6	24.7	23.9	24.5	17.4	19.0	18.0	19.4	6.4	6.5
8	-	15	35.8	37.9	36.3	37.6	26.7	29.0	26.9	28.8	14.3	11.4
15	-	25	33.6	35.7	33.8	35.3	29.0	30.4	29.4	30.7	12.6	11.9
25	-	50	52.5	44.7	70.0	51.7	61.3	38.0	84.0	- ¹	57.1	30.4
50	-	70	39.0	34.3	51.6	45.6	33.1	33.0	29.1	-	25.8	27.7
70	-	85	32.2	33.8	47.1	42.6	- ²	25.1	24.7	-	20.3	22.4
85	-	120	18.6	27.4	34.9	46.6	-	25.5	12.7	-	15.2	19.1
-10	-	120	31.9	32.6	43.4	41.8	35.1	28.1	32.5	29.8	24.2	20.5

¹Abnormal termination of transient after 40.7 s due to water property error when accumulator got empty

²Abnormal termination of transient due to water property error

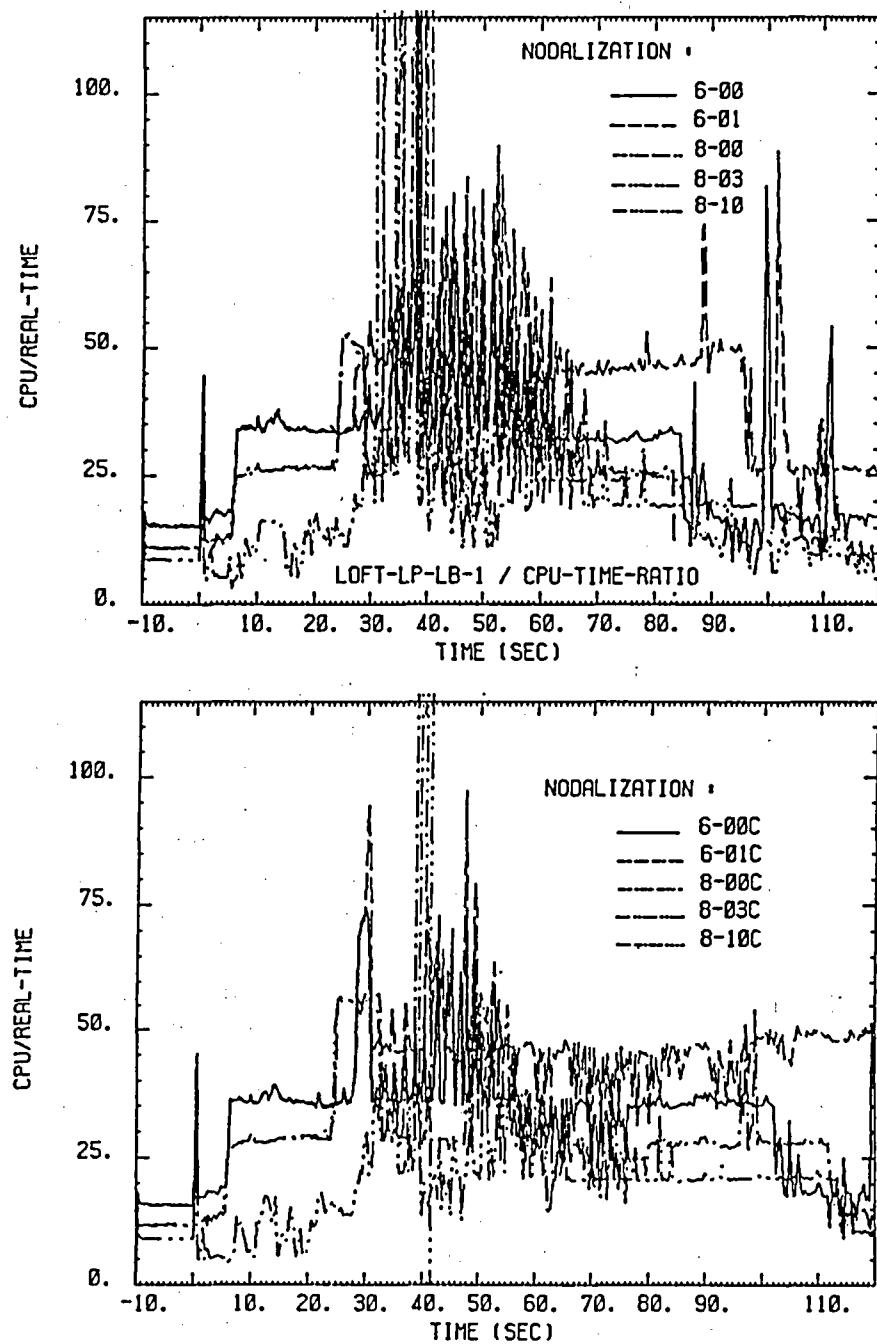


Figure 3.2: CPU-time to Real time ratio vs. time

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

the case of all the nodalizations which are not taking into account heat capacity effects (normal nodalization). One easily recognizes very strong instabilities of all the calculations in the interval 30 to 65 seconds (with peak values between 30 and 40 seconds) probably due to the cold water injection out of the accumulator into the saturated flow of the intact loop cold leg. High non-equilibrium leads to the above mentioned relatively high RTM-value in this interval of the transient. The overall benefits of the simplified versions of nodalization can well be noticed in the time regions -10 to 30 seconds and 70 to 120 seconds.

In Fig. 3.2b, the RTM-values for all the C-versions have been plotted (i.e. the versions of nodalization where the heat capacity effects of the wall material of the vessel have been taken into account). Obviously, compared to fig. 3.2a, the large number of oscillations in the region of 30 to 65 seconds are damped significantly for all types of nodalizations.

In both plots, the very narrow first peaks at nearly zero seconds are probably due to the thermodynamic non-equilibrium during the subcooled blowdown phase which only lasted some hundreds of milliseconds after the opening of the break valves.

A second basic criteria for the quality of a certain nodalization is the "mass error" which is a measure for the numerical accuracy of the code because it represents a check of the mass balance in all of the system volumes. Therefore, in Figs. 3.3a and 3.3b, the mass errors have been plotted versus the experimental time for all the calculations using different nodalizations, referred to in table 2.1. In general, quantitatively no significant differences have been found between the results with the normal and the "C" nodalizations. The absolute

value of the mass error never exceeded values of 0.8 kg and is not inverse-proportional to the sophistication of the nodalization, i.e. a higher sophisticated nodalization automatically leads to smaller mass-errors. For the "C" versions, this error remains nearly constant after 40 seconds, i.e. during the refill phase of the experiment, but its stationary value strongly depends on the nodalization. But in any case, because the total mass inventory of the LOFT system is in the order of 7 tons, a "numerical loss" of not more than one kilogram is negligible.

3.3 Discussion of the Code-Predictions of the Main Events

Before starting the discussion of the performance of RELAP5/Mod2 in calculating the main events of the experiment, first, in Fig. 3.4, a graphic representation of the main trip setpoints has been plotted where a value of nearly one indicates that the trip is set. Shown here are the settings of the break valves, which opened at zero seconds, the power-trip at 0.13 seconds (difficult to distinguish from the break valve line) and the pump-trip at 0.63 seconds. The behaviour of the ECC-system is indicated by the - - - line. For the accumulator, its value is 0.66 and for the LPIS 0.33. The accumulator started injection at 17.5 seconds, followed by the LPIS at 32.0 seconds (trip value one). The trip curve falls back again to 0.33 when the accumulator has emptied at nearly 40 seconds (the exact time is calculated by RELAP5/Mod2 and therefore is slightly depending on the nodalization of the problem; see fig. 3.4a and b) and the LPIS remained functioning.

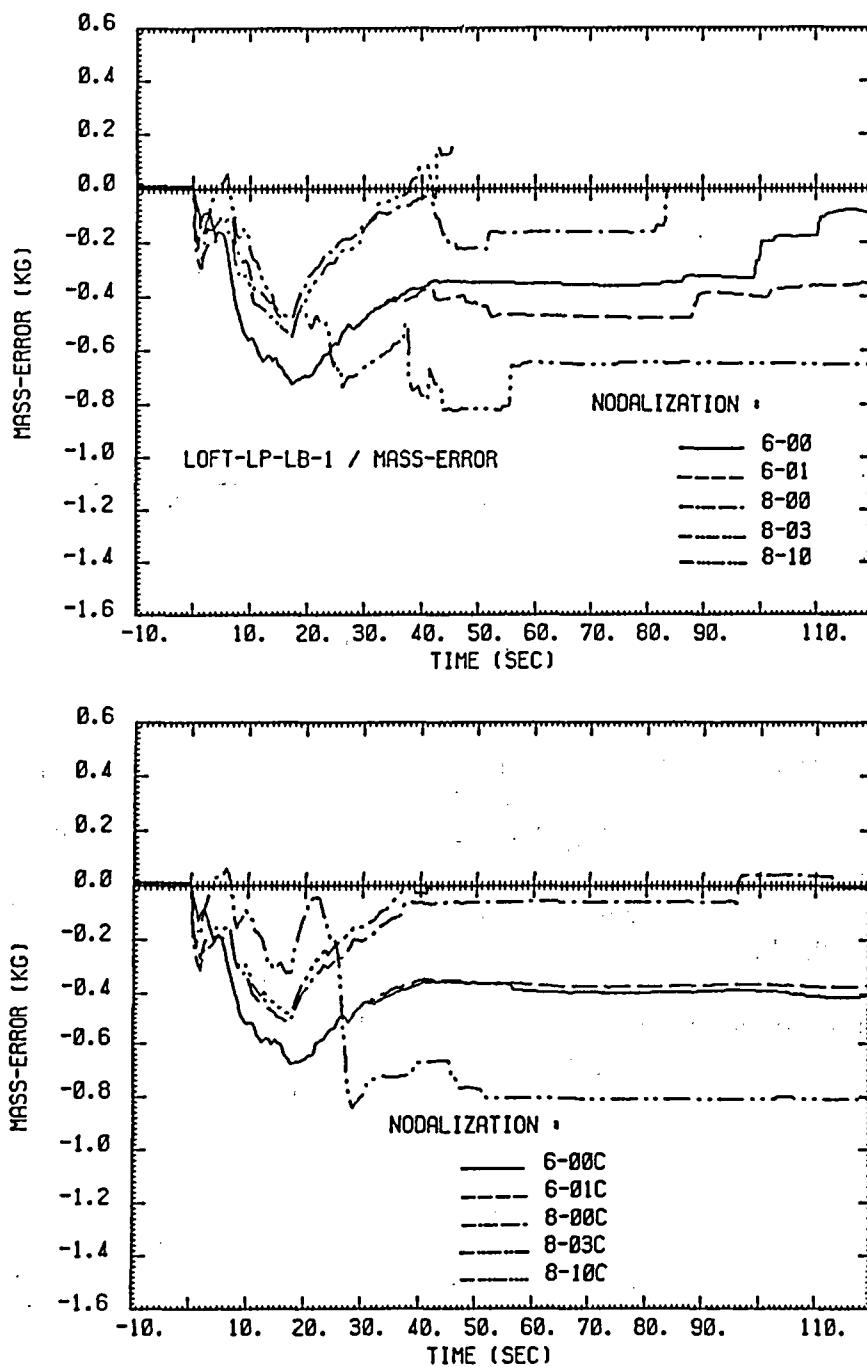


Figure 3.3: Mass error as defined by RELAP5/Mod2 vs. time

- a) by neglecting wall heat capacity
- b) by taking into account wall heat capacity ("C")

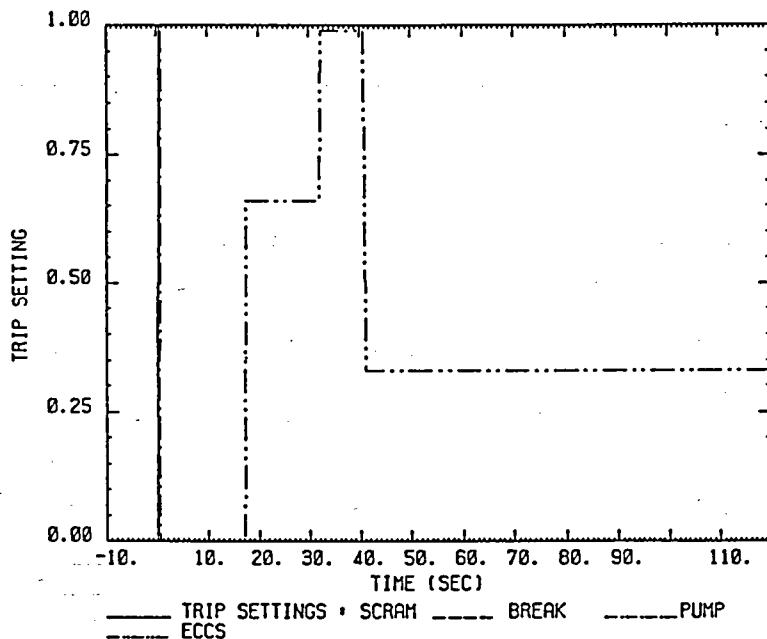


Figure 3.4: Trip setpoints for experiment LP-LB-1

In Table 3.2, some main events have been listed and their occurrence during the experiment (time and value) have been compared to the equivalent code results using the different nodalizations as given in table 2.1. The setpoints of the different trips are again listed in table 3.2. First, one should notice that in contradiction to the experiment where both the reactor power and the accumulator injection have been initiated by an actual pressure-dependent setpoint, for the calculation we have used a time-dependent setpoint retrieved from the experiment thus avoiding a multiplication of errors (if the pressure is predicted wrong, this error will heavily influence the predictions of the other parameters in the following time sequences).

3.3.1 Calculation of Mass Flows in the Broken Leg

We start our comparison with the broken loop and have to look at the peak mass-flow rates as well as at the end of the subcooled break flows in the hot and cold legs.

For all of the different runs, the end of the subcooled break flow in the hot leg lies between zero and 0.4 seconds. In the cold leg, the end of subcooled break flow occurs between 3.4 and 4.2 seconds, slightly depending on the selected nodalizations; the smallest values have been calculated by the 8-03 nodalizations where the cold leg is represented by only one single volume thus invalidating a correct positioning of the measurement station.

For all the nodalizations, the peak value of the mass-flow has occurred at the first printed time step after initiation of the transient (0.4 s) and has to be compared to a reference value measured at 0.25 seconds of the

transient. All the nodalizations except 8-03 and 8-03C produce very similar peak values of approximately 536 kg/s from the cold leg and 170 kg/s from the hot leg which are quite close to the measured values of 515 kg/s for the cold leg and 184 kg/s for the hot leg, respectively; the values of the 8-10 nodalization are slightly higher and lower. Even for the nodalizations 8-03 and 8-03C with their strongly simplified piping in the intact and broken loops, the peak value for the cold leg is less than 10% off whereas the peak value for the hot leg exceeds the experimental data at least 30%.

As a general trend, it can be observed that only a severe simplification of the piping of the broken loop tends to give higher predictions of the peak break flows, especially in the hot leg, whereas smaller simplifications seem not to affect the accuracy of the calculation (compare results 6-00 and 8-00, the latter with a simplified piping in the broken loop). A severe reduction of the number of volumes and junctions in the broken loop of nodalization 8-03 has lead to an increase of the peak value of the cold and hot leg results which reached overestimations of nearly 30% for the hot leg. On the other hand, one has to keep in mind that two-phase flow mass flow measurements both under stationary and transient conditions are increasingly difficult tasks because the mass flow measurement is the result of a multiplication of two independent measurements which are assumed to produce area averaged quantities. These independent measurements are the momentum flux measurement by drag bodies (or the velocity measurement by mini-turbines) and the density measurement by a three beam X-ray densitometer. Both signals are erroneous, especially in high void flow regimes. Furthermore, it is assumed that the product of each of the individual two integrals (i.e. the area-average

of the measurements) is equal to the integral of the product of the two variables, an assumption which is fulfilled rather seldom. The quantification of the error of the mass-flow measurements is quite difficult because its dependence of a variety of parameters like flow-regime, void fraction, velocities, etc.

A better picture of what is going on in the broken leg can be achieved by looking at the integral mass losses through the break at different times as listed in table 3.2 where both code predictions and experimental values have been determined by simply summing up the product values of time-step times the instantaneous mass flow at the two breaks. Here, the general trend is that the code calculated higher losses for the first 30 seconds and then stayed on a certain level (see also figs. 3.40a and b) and finally underpredicted the actual mass losses through the break. In fact, the sign of the flow through the break even changed, indicating a small amount of backflow out of the containment into the primary system due to slightly higher containment pressures (defined as boundary conditions using the experimental data of experiment LP-LB-1) than calculated by RELAP5/Mod2 for the primary system. Because the containment has been modeled as an additional time dependent volume downstream of the break, this backflow is not "unphysical" with respect to the special "LOFT-system" as described by our nodalization schemes. To indicate the occurrence of the flow reversal, the calculated peak mass loss and the time of its occurrence have been given in table 3.2.

The code calculated similar mass losses for the different nodalizations. In fact, two groups may be distinguished, the results of the most detailed 6-00 versions which have produced slightly higher mass losses than the more simplified 8-0... versions.

Table 3.2: Comparison of characteristic parameters inferred from experiment with equivalent RELAP5/Mod2 -results of different nodalizations

EVENT	MEAS. DATA		RELAP5/Mod2 CALCULATIONS										
	Q	unit		6-00	6-01	8-00	8-10	8-03	6-00C	6-01C	8-00C	8-10C	8-03C
Blowdown valves open	T	s	0.0										
Reactor scrammed ¹	T	s	0.13										
Stop coolant pumps	T	s	0.6										
Start accumul. inject. ¹	T	s	17.5										
Start LPIS	T	s	32.0										
End of subc. break flow													
cold leg	T	s	3.5	4.0	4.2	4.2	3.8	3.4	4.0	4.0	4.2	4.0	3.4
hot leg	T	s	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.6	1.0
Peak mass flow													
broken loop _{cold leg} ²	T	s	0.25	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
broken loop _{hot leg} ²	V	kg/s	514.7	536.1	536.1	534.8	537.0	560.1	536.2	536.2	534.7	537.0	559.6
	T	s	0.25	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	V	kg/s	184.1	170.6	170.6	170.3	164.7	233.5	170.6	170.6	170.2	164.7	242.9

⁰Symbol in the Q-row stands for T=time and V=value

¹during the experiment tripped by system pressure signal

²Differences may be due to different time steps of the measurement and the calculation

Table 3.2: ...cont.

EVENT	MEAS. DATA		RELAP5/Mod2 CALCULATIONS											
			Q	unit	6-00	6-01	8-00	8-10	8-03	6-00C	6-01C	8-00C	8-10C	8-03C
break mass loss (5 s) (10 s) (30 s) (70 s) (120 s)	V	ts	1.91		2.36	2.36	2.33	2.33	2.42	2.37	2.37	2.34	2.33	2.43
	V	ts	2.79		3.37	3.37	3.22	3.24	3.32	3.36	3.36	3.23	3.23	3.27
	V	ts	4.67		5.14	5.15	4.95	4.82	4.98	5.10	5.10	4.81	4.82	4.97
	V	ts	5.45		5.30	5.32	4.95	4.94	4.98	5.55	5.52	5.22	— ³	5.19
	V	ts	5.93		5.30	5.36	4.97	4.96	5.00	5.54	5.52	5.24	—	5.17
Peak mass loss _{break} ⁴	T	s	—		53.6	40.4	55.6	38.4	30.8	64.4	65.6	61.5	—	57.2
	V	kg	—		5.532	5.31	4.96	4.95	4.99	5.55	5.52	5.23	—	5.19
Minimum collapsed liq. lvl. reached (hot chann.) (average chann.)	T	s	— ⁵		6.8	6.8	9.6	6.8	6.8	6.4	6.4	7.2	6.8	7.2
	V	%	—		3.6	3.5	2.9	5.0	2.9	3.9	3.9	4.2	5.1	4.2
	T	s	—		6.8	6.8	9.6	6.8	6.8	6.4	6.4	6.8	6.4	7.2
	V	%	—		3.5	3.6	3.6	4.8	4.6	4.2	4.2	4.6	5.3	4.3

³Abnormal termination after 40.67 seconds of transient due to "water property error"⁴Calculated integral Break losses reached a defined peak value because flow reversal occurred due to negative pressure difference between system pressure and suppression tank pressure⁵no experimental value available

Table 3.2: ... cont.

EVENT	MEAS. DATA			RELAP5/Mod2 CALCULATIONS									
	Q	unit		6-00	6-01	8-00	8-10	8-03	6-00C	6-01C	8-00C	8-10C	8-03C
Pressurizer emptying ⁶ -pressure	T V	s MPa	15.0 7.6	14.4 7.8	14.4 7.8	17.6 3.9	17.4 4.0	17.6 3.7	14.4 7.9	14.4 7.9	17.6 4.0	17.6 4.0	18.8 3.5
Accumulator emptying	T	s	40.0	40.0	40.0	39.6	39.2	37.2	42.4	42.4	41.2	40.7 ⁷	39.6
Peak cladding temp. ^{8,9}	T V	s K	26.4 1238	6.8 1090	6.8 1090	26.0 1097	41.2 1118	37.6 1137	6.4 1084	6.4 1084	6.8 1074	28.0 1081	24.8 1095
Blowdown peak cladding temperature ¹⁰ in hot channel level-02	T V	s K	5.8 844	6.8 691	6.8 691	13.6 705	14.4 720	8.0 714	6.4 683	6.4 683	7.2 666	14.4 654	1.6 754
level-11	T V	s K	5.8 1114	7.2 725	7.2 725	13.6 739	13.6 758	7.2 954	6.8 718	6.8 718	1.2 722	13.6 747	6.4 955
level-21	T V	s K	8.3 1162	6.8 1037	6.8 1037	12.4 1043	16.4 833	7.2 1040	6.4 1033	6.4 1033	6.8 1029	14.4 818	6.4 1039

⁶Empty point for the calculation is a pressurizer level less than 0.01 m⁷Abnormal termination due to "water property error" when accumulator got nearly empty⁸Experimental value at level-24. Indicated temperature is an average of thermocouples TE-J08-024 and TE-F08-024⁹All predicted peak cladding temperatures at level-31¹⁰Reference values are averages of several temperatures inferred from thermocouple signals at the same axial level but different radial positions

EVENT	MEAS. DATA			RELAP5/Mod2 CALCULATIONS									
	Q	unit		6-00	6-01	8-00	8-10	8-03	6-00C	6-01C	8-00C	8-10C	8-03C
level-24	T	s	12.8	6.8	6.8	11.2	9.2	7.2	6.4	6.4	6.8	6.8	6.4
	V	K	1230	1054	1054	1059	1045	1056	1047	1047	1042	1032	1061
level-27	T	s	13.3	6.8	6.8	11.2	9.2	7.2	6.4	6.4	6.8	6.8	6.4
	V	K	1123	1082	1082	1085	1071	1086	1075	1075	1067	1056	1086
level-31	T	s	12.8	6.8	6.8	11.2	9.6	7.2	6.4	6.4	6.8	6.4	6.8
	V	K	1110	1090	1090	1090	1081	1091	1084	1084	1074	1065	1093
level-39	T	s	11.8	6.8	6.8	9.6	10.0	7.2	6.4	6.4	6.8	6.8	6.6
	V	K	1079	1023	1023	1025	1016	1037	1017	1017	1018	1005	1038
level-43.8	T	s	12.3	6.4	6.4	6.8	1.2	7.2	6.0	6.0	6.4	1.2	6.4
	V	K	993	949	950	947	731	950	944	944	945	731	954
level-49	T	s	12.3	0.8	0.8	0.8	0.8	1.2	0.8	0.8	0.8	0.8	1.2
	V	K	946	683	683	699	687	721	682	682	698	687	690
level-62 ¹¹	T	s	7.8	—	—	—	—	—	—	—	—	—	—
	V	K	770	—	—	—	—	—	—	—	—	—	—

¹¹no significant peak of the cladding temperature found

Table 3.2: ... cont.

EVENT	MEAS. DATA		RELAP5/Mod2 CALCULATIONS										
	Q	unit	6-00	6-01	8-00	8-10	8-03	6-00C	6-01C	8-00C	8-10C	8-03C	
level-24	T	s	12.8	6.8	6.8	11.2	9.2	7.2	6.4	6.4	6.8	6.8	6.4
	V	K	1230	1054	1054	1059	1045	1056	1047	1047	1042	1032	1061
level-27	T	s	13.3	6.8	6.8	11.2	9.2	7.2	6.4	6.4	6.8	6.8	6.4
	V	K	1123	1082	1082	1085	1071	1086	1075	1075	1067	1056	1086
level-31	T	s	12.8	6.8	6.8	11.2	9.6	7.2	6.4	6.4	6.8	6.4	6.8
	V	K	1110	1090	1090	1090	1081	1091	1084	1084	1074	1065	1093
level-39	T	s	11.8	6.8	6.8	9.6	10.0	7.2	6.4	6.4	6.8	6.8	6.6
	V	K	1079	1023	1023	1025	1016	1037	1017	1017	1018	1005	1038
level-43.8	T	s	12.3	6.4	6.4	6.8	1.2	7.2	6.0	6.0	6.4	1.2	6.4
	V	K	993	949	950	947	731	950	944	944	945	731	954
level-49	T	s	12.3	0.8	0.8	0.8	0.8	1.2	0.8	0.8	0.8	0.8	1.2
	V	K	946	683	683	699	687	721	682	682	698	687	690
level-62 ¹¹	T	s	7.8	—	—	—	—	—	—	—	—	—	—
	V	K	770	—	—	—	—	—	—	—	—	—	—

¹¹no significant peak of the cladding temperature found

Table 3.2: ... cont.

EVENT	MEAS. DATA		RELAP5/Mod2 CALCULATIONS										
	Q	unit	6-00	6-01	8-00	8-10	8-03	6-00C	6-01C	8-00C	8-10C	8-03C	
Quench front ¹⁴ during reflooding in hot channel level-02 ¹⁵	T	s	33.5	—	30.5	31.2	34.0	26.2	26.1	31.8	31.0	25.2	
	V	K	730	—	580	570	580	570	571	535	535	575	
	T	s	48.3	33.2	42.2	32.5	40.2	55.0	29.5	29.7	32.5	32.3	49.8
	V	K	980	580	685	610	630	710	620	570	570	563	825
	T	s	55.5	55.5	68.0	62.5	52.0	71.5	65.5	89.5	81.0	— ¹⁶	75.0
	V	K	935	755	630	760	745	760	745	635	835	—	770
	T	s	64.5	62.5	75.5	69.0	62.0	79.0	78.6	100.5	90.0	—	84.7
	V	K	810	755	615	760	781	740	785	640	755	—	773
	T	s	65.7 ¹⁷	70.5	83.0	77.5	71.0	88.3	88.0	111.5	98.5	—	94.5
	V	K	805	743	625	755	724	725	712	612	724	—	732
level-31	T	s	67.5 ¹⁸	76.5	90.0	85.5	78.5	94.5	94.5	118.0	107.0	—	102.5
	V	K	850	725	615	720	713	743	712	612	695	—	722
level-39	T	s	61.5 ¹⁹	76.5	91.0	86.0	74.5	94.0	85.0	106.0	95.0	—	100.5
	V	K	850	765	622	765	776	763	730	643	720	—	772

¹⁴Time and value of "knee temperature"¹⁵— sign means no significant increase of the cladding temperatures¹⁶Run terminated before quench front has reached this level¹⁷Quench time varies between 62 and 70 s at the different thermocouples of level-27¹⁸Quench time varies between 61 and 74 s at the different thermocouples of level-31¹⁹Quench time varies between 53 and 69 s at the different thermocouples of level-39

Table 3.2: ... cont.

Table 3.2: ... cont.

EVENT	MEAS. DATA		RELAP5/Mod2 CALCULATIONS										
	Q	unit	6-00	6-01	8-00	8-10	8-03	6-00C	6-01C	8-00C	8-10C	8-03C	
level-43.8	T	s	60.8 ²⁰	57.5	72.0	68.5	43.0	71.5	62.5	79.0	71.5	— ²¹	75.5
	V	K	825	765	700	760	656	740	752	612	670	—	740
level-49	T	s	46.0 ²²	— ²³	— ²³	— ²³	35.0	37.5	28.2	27.5	34.5	—	25.0
	V	K	730	—	—	—	550	594	651	657	511	—	548
level-62 ²³	T	s	37.5	—	—	—	—	—	—	—	—	—	—
	V	K	580	—	—	—	—	—	—	—	—	—	—
in avg. channel level-11	T	s	33.0	—	—	37.2	30.0	44.2	26.0	26.5	28.2	29.0	28.5
	V	K	645	— ²³	— ²³	572	560	594	532	530	600	528	605
level-21	T	s	33.0	35.0	42.5	41.5	42.0	54.5	28.8	31.0	42.5	30.0	45.1
	V	K	550	608	652	715	670	670	655	582	590	548	660
level-28	T	s	39.0	48.0	58.0	49.2	43.0	54.0	36.0	49.0	28.0	—	29.5
	V	K	580	720	605	595	665	635	672	625	600	—	548
level-39 ²⁴	T	s	39.0	26.5	37.5	(31.8)	(30.5)	37.5	27.5	27.2	30.0	—	28.5
	V	K	580	642	625	(543)	(545)	570	623	620	515	—	525

²⁰Quench time varies between 41 and 51 s at the different thermocouples of level-43.8²¹Run has been terminated before the quench front has reached level²²Quench time varies between 42 and 52 s at the different thermocouples of level-49²³No significant increase of cladding temperature²⁴Values in brackets indicate the "quenching" of a rod which didn't heat-up very much

3.3.2 Minimum Collapsed Liquid Level

The next value of interest is the time when the collapsed liquid level in the core region has reached its first minimum, i.e. when the core region was nearly emptied during the blowdown phase of the transient. Unfortunately, for the collapsed liquid level (or equivalent to it, the average liquid fraction in the core region), no experimental data is available. In table 3.2, the collapsed liquid level is given in percents relative to the total heated core height of 1.63 m. The comparison of the results with the different nodalizations indicated no severe discrepancies with respect to the values of the minimum collapsed liquid levels. Their ranges varied between 2.9% and 5.1% in the hot and 3.5% and 5.3% in the average channels. No significant trends have been observed with respect to the sophistication of the nodalizations. The minimum collapsed liquid level has been reached between 6.4 and 7.2 seconds after initiating the transient except for runs 8-00 where it took 9.6.

3.3.3 Emptying Points of Pressurizer and Accumulator

Two of the significant events during the LOFT-experiment have been found to be the emptying of the pressurizer and the accumulator.

The pressurizer emptied during the experiment at about 15.0 seconds after the opening of the break valves; at this moment, pressure in the pressurizer has decreased to a value of 7.6 MPa. RELAP5/Mod2 calculated this emptying point between 14.4 seconds for the most elaborated 6-00 and 6-01 nodalizations and 18.8 seconds for the most simplified 8-03C but not for the equivalent (with respect to the number of volumes and junctions) 3-02

nodalization, where this value was 17.6 seconds. It is not surprising that the time for emptying the pressurizer strongly depended on the chosen nodalization. The pressures in the pressurizer as calculated by the code have been found to be quite close to the experimental data for the 6-00 and 6-01 nodalizations, for the 8-0... series of nodalizations with their crude modelling especially in the pressurizer, the RELAP5/Mod2 -calculations of the pressurizer pressures are rather poor, namely around 4 MPa or even less instead of the measured 7.6 MPa (the 4 MPa is comparable to the system pressure at the time of emptying point).

The accumulator empties at about 40 seconds after the initiation of the experiment. In general, the code predictions seem to be sufficiently close to this experimental setpoint. This relatively good agreement of the code results with the experimental findings is not at all surprising because the emptying time has been tuned once for all for the 6-00 version of nodalization by increasing the forward and reverse flow energy loss coefficients of the accumulator junction from 13, as given in the original EG&G, to about 125.

3.3.4 Peak Cladding Temperatures During the Blowdown Phase

Peak cladding temperatures of more than 1200 K have been measured by only two of the six thermocouples radially distributed in fuel assembly 5 (center of core) at core level 24, i.e. 24 inches from the bottom of the core; one indicated 1220 K and the other the maximum value of 1238 K.

The calculated peak cladding temperatures always occurred at level-31, i.e. 31 inches from the bottom of the core (by the way, for the original EG&G nodalization of the

core which was used for nearly all of the pre- and post-test analyses of the LOFT experiments, core levels-24 and levels-31 fall in the same volume of the nodalization and consequently indicated the same calculated temperatures). Their values only depend on the chosen nodalization and vary between 1074 K (8-00C) up to 1137 K (8-03), where the "C" versions always calculated slightly lower temperatures. The highest values have been predicted by the most simplified 8-03 and 8-03C versions of nodalizations.

The next values of interest are the peak cladding temperatures reached at different core heights during the blowdown period of the experiment which occur in the first 15 seconds after opening the break valves. With respect to the central core region (hot channel), the blowdown peak cladding temperatures usually have been underpredicted by RELAP5/Mod2 in the range between 50 and 350 K at all core levels. At the bottom and the top of the core, for some runs no significant increase of the cladding temperatures has been calculated. With respect to the outer core (average channel), for all nodalizations, the blowdown peak cladding temperatures have been underpredicted between approximately 100 K and 200 K.

At the higher levels of the LOFT-core, top-down rewetting took place during the blow-down period of the experiment. This top-down quenching has not been calculated by RELAP5/Mod2 (next item in table 3.2). Whereas at very high core levels (e.g. level-62), no significant increase of the cladding temperatures at all has been calculated, at slightly lower levels (49 and 43.8) no characteristic drops of the cladding temperatures have been predicted by RELAP5/Mod2. Somehow exceptional are the results of nodalizations 8-10 and 8-10C which have indicated no strong increases of the cladding temper-

atures even during the blow-down phase for all levels above level-43.8.

3.3.5 Quench Front Positions During the Reflooding Phase

The quench front positions during the reflooding phase of the experiment have been found to be one of the most sensitive parameters of the calculations. Therefore, the last item of table 3.2 will show the comparison between the experimental results (time and value at the "knee-point" of the temperature trace of one individual thermocouple at a certain axial core level) and the equivalent code predictions at 10 different core levels where thermocouples have been installed. Because at a certain core height the core-wide radially distributed thermocouples may indicate different quench front positions, we have used an averaged value for time and temperature at one core level but we have given the range of quench times of the different radially distributed thermocouples at one core level in the footnotes, if necessary.

The comparison of experimentally inferred and the RELAP5/Mod2 -calculated QF-positions using our different nodalizations have shown the largest discrepancies of all the variables listed in table 3.2. The calculated QF-positions (i.e. times at a given core level) range from the quite accurate ones of the 6-00 and 8-00 nodalizations to the rather poor ones using the "C"-versions of nodalization, i.e. taking into account the heat capacity effects of the vessel walls. Here, at least in the center of the core between levels-21 and levels-31, the quench-times have been overpredicted by RELAP5/Mod2 more than 20 seconds. The QF-temperatures calculated by RELAP5/Mod2 are usually 50 K to 200 K lower than the experimentally inferred ones.

For the average channel, the temperature increase as calculated by RELAP5/Mod2 was usually higher than the cladding temperatures measured during experiment LP-LB-1.

3.4 Time Behaviour of Significant Thermo-Hydraulic Parameters

3.4.1 Cladding Temperatures

As we already have observed in table 3.2, RELAP5/Mod2 usually has underpredicted the peak-cladding temperatures in the center channel of the core in the order of 50 K to 200 K. By looking at the time history of the cladding temperatures at different axial heights of the core, it will become even more clear that rather significant discrepancies between the RELAP5/Mod2 calculations using different nodalizations and the experimental data exist.

Due to our specific nodalization of the core region which is identical for all of the investigated schemes, RELAP5/Mod2 is able to calculate the cladding temperatures in only two different representative channels, namely the "hot channel" attributed here to the center-box 5 and the "average channel" which can be attributed to one of the side boxes of the LOFT core; for the comparison with experimental data, we have used the side-box 4 (in principle, any other of the four side-boxes or an average of all of them could be used).

Let us start our discussion of the RELAP5/Mod2 calculations of the cladding temperatures in the "hot channel", i.e. box 5 of the LOFT core.

Cladding Temperatures in the Center Box

In Figs. 3.5 to 3.14, the time traces of the cladding temperatures at 10 different core heights in the center box (box 5) as calculated by RELAP5/Mod2 ("hot channel") have been compared to the average temperature (!) at the specific core height where the averaging process has been described in chapter 3.1, using the different nodalizations as listed in table 2.1. For the sake of better readability, for each axial position two figures are given in which it is shown five comparisons of "non C"-type (plot a; versions 6-00, 6-01, 8-00, 8-03 and 8-10) and again five comparisons of "C"-type nodalizations (plot b; versions 6-00C, 6-01C, 8-00C, 8-03C and 8-10C), i.e. where the heat capacity effects of the vessel material have been taken into account ("C"-type) and where these have been neglected.

At axial level 02, i.e. 2 inches from the bottom of the core, the experimental cladding temperatures have undergone a significant temperature increase of nearly 300 degrees during the blowdown phase of the experiment, which RELAP5/Mod2 has failed to calculate both in time behaviour and in value. Whereas the experimentally inferred cladding temperature remained at a high temperature level during nearly 40 seconds, independently of the nodalization, the code calculated a quite cyclic behaviour. The final "cool-down" of the calculated cladding temperatures occurs nearly at the same time the QF reached the first level during the experiment; it occurs some 5 seconds earlier for the "C"-version calculations. It is worth noticing the RELAP5/Mod2 calculations using the most detailed nodalizations 6-00 and 6-00C (two pumps, most sophisticated modeling of the steam generator secondary side, broken loop with the highest number of volumes) seem to

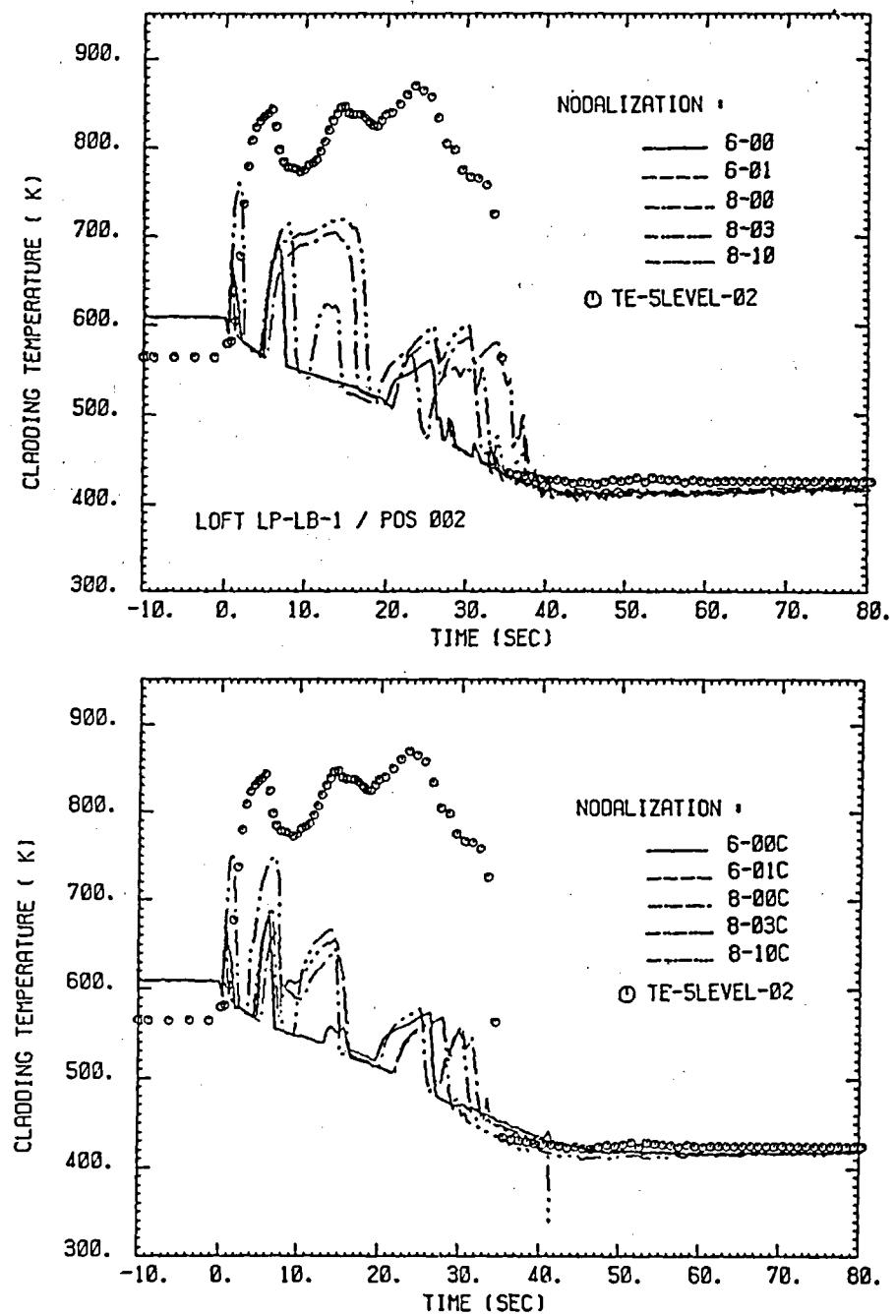


Figure 3.5: Hot-channel cladding temperatures vs. time at axial level 02
compared with the equivalent reference temperature
 a) by neglecting wall heat capacity
 b) by taking into account wall heat capacity ("C")

produce the poorest results.

Generally, RELAP5/Mod2 seems to calculate too much water in this lowest level which disables any significant core heat-up. The reason for this overprediction of the water content may be due to the size of this hydrodynamic volume which is around two times the size of a volume in the center of the core.

The "predicting capabilities" seem to have only slightly been improved at the following axial level 11 (figs. 3.6). Again, except for nodalizations 8-03 and 8-03C, RELAP5/Mod2 -calculations are poor with respect to both time behaviour and value. Using nodalizations 8-03 or 8-03C, RELAP5/Mod2 has produced the right time behaviour of the cladding temperatures but still has underpredicted the temperature rise at least 200 K. The time of final "cool-down" varies between 30s (6-00C) and 56s.(8-03).

Things have changed completely at axial level 21 (fig. 3.7). Here, except for nodalizations 8-10 and 8-10C, RELAP5/Mod2 has been able to reproduce at least qualitatively the time behaviour of the cladding temperature but still has underpredicted the temperature level for at least 120 K. The times of final quenching vary in a range of 53s (8-10) and more than 80s, depending on the nodalization used for the calculation.

For the next four axial positions (24, 27, 31 and 39 inches from the bottom of the core), figs. 3.8 to 3.12, the predicting capabilities of RELAP5/Mod2 may be characterized by satisfactorily describing the qualitative time-behaviour of the cladding temperatures but still missing it quantitatively.

As mentioned above, the highest cladding temperature has been measured at level-24 (the average value of the signals of two of the radially distributed thermocouples at this ax-

ial level) to be 1240 K. All of the calculations have missed this value at least 180 K, the highest underpredictions being those of the 6-00 and 6-00C nodalizations, i.e. the most detailed versions of nodalization (straight lines in both of the plots). On the other hand, the calculation using the 6-00 nodalization came closest when tracing the QF position, where, except version 8-10, all the other calculations failed significantly.

For levels 27, 31 and 39 (figs. 3.9 to 3.11) calculated and experimental inferred values of the cladding temperatures came closer. Whereas for the nodalizations without taking into account heat capacity effects, the discrepancies are less than 50 K (underprediction), for the "C" versions we still have an underprediction of more than 100 K. In addition to this, again the "C" versions have done a worse job in calculating the time of final quenching of the cladding, i.e they usually were off between 30 and 50 seconds compared to the "normal" versions which have overpredicted the final quench not more than 30 seconds.

The last three levels under investigation, levels 43.8, 49 and 62 (inches from the bottom of the core) from the experimental side of view are characterized by a significant top-down quench following the heat-up of the whole core during the blow-down phase of the experiment (figs. 3.12 to 3.14). This top-down quench is only slightly indicated in the experimental results at level 43.8 (due to the averaging process described in chapter 3.1) but clearly seen in the references at levels 49 (fig. 3.13) and 62 (fig. 3.14).

Generally, RELAP5/Mod2 has been unable to calculate this top-down quench; the qualitatively reasonable reproduction of the cladding - temperatures generated by RE-

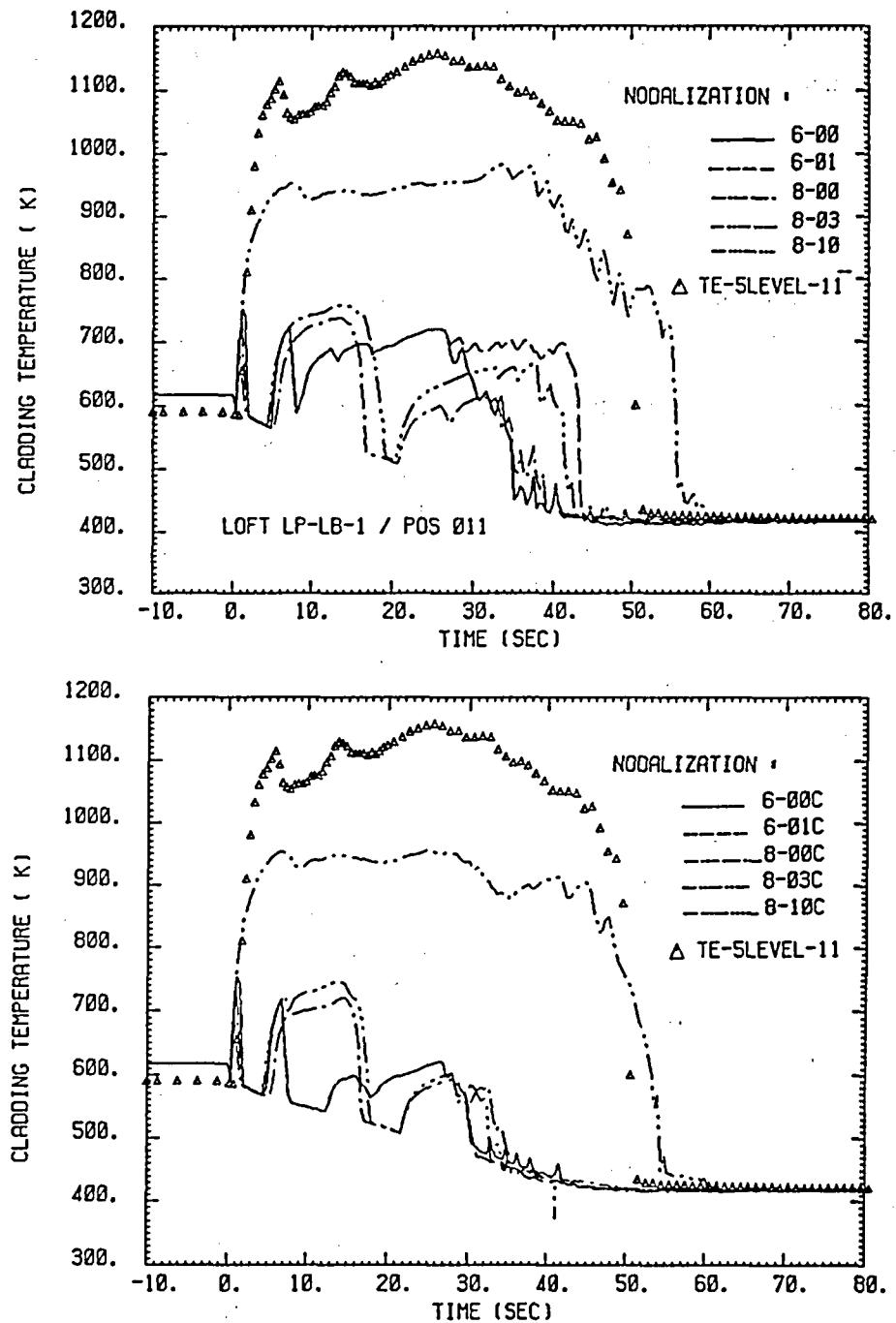


Figure 3.6: Hot-channel cladding temperatures vs. time at axial level 11
compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

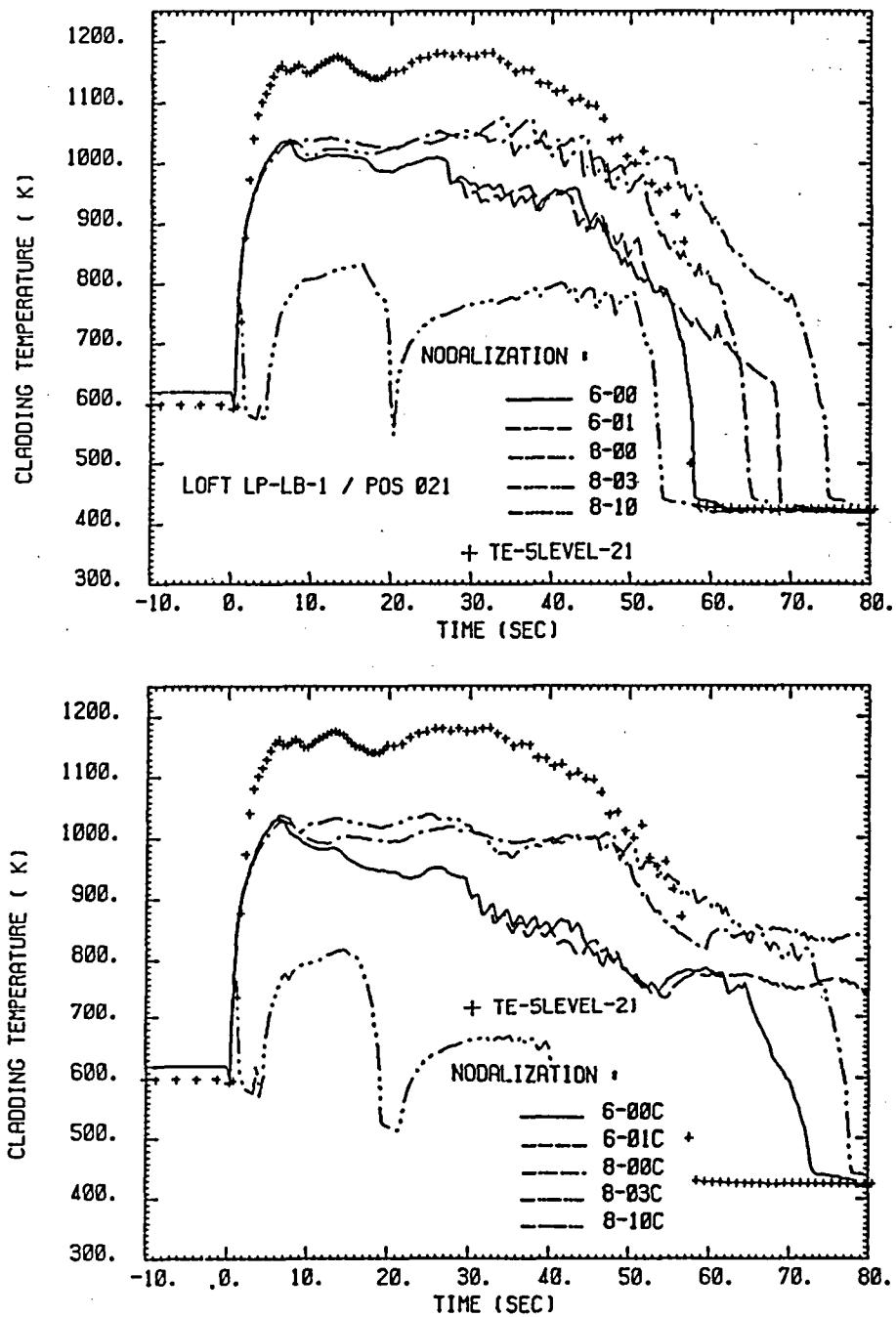


Figure 3.7: Hot-channel cladding temperatures vs. time at axial level 21 compared with the equivalent reference temperature

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

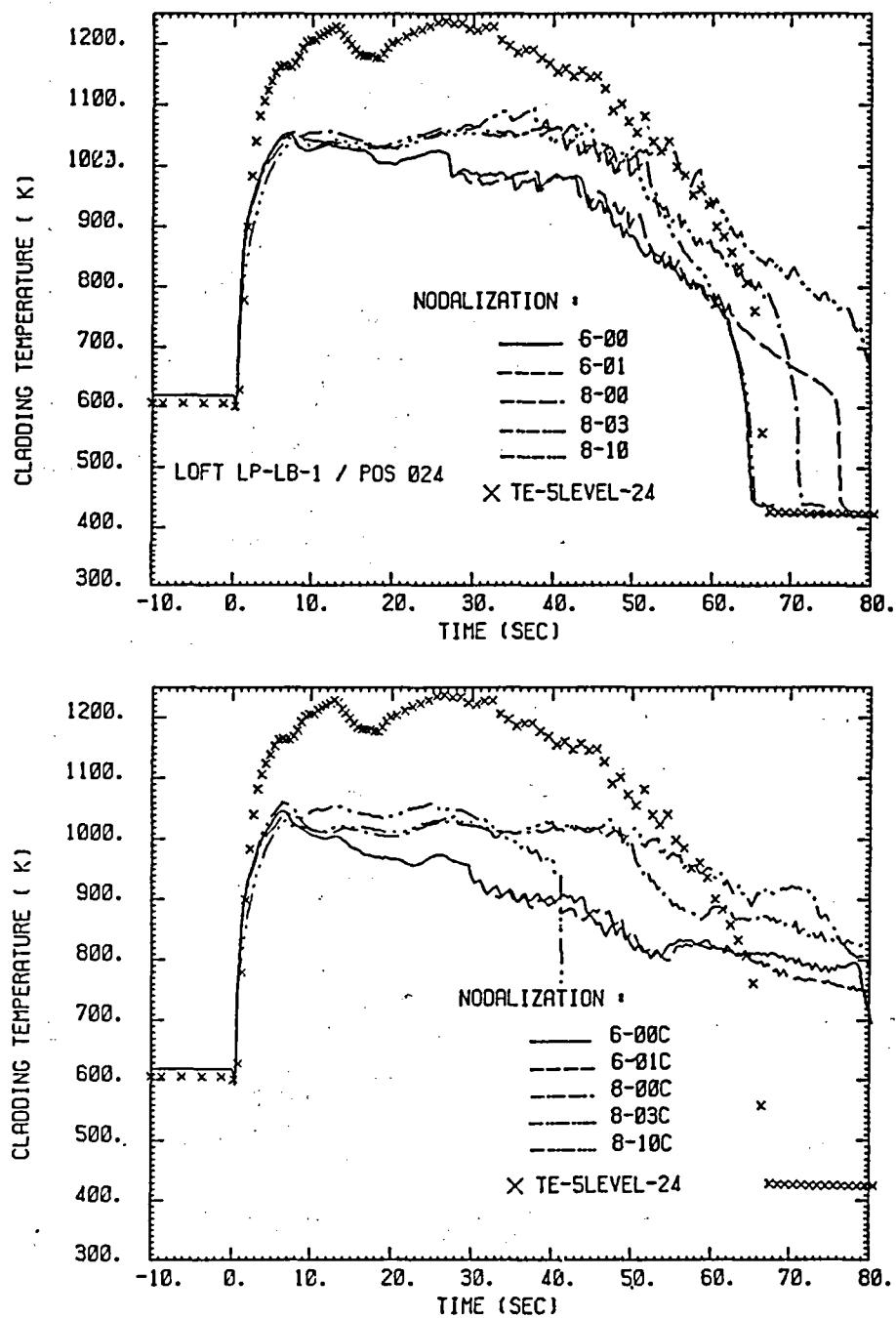


Figure 3.8: Hot-channel cladding temperatures vs. time at axial level 24
compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

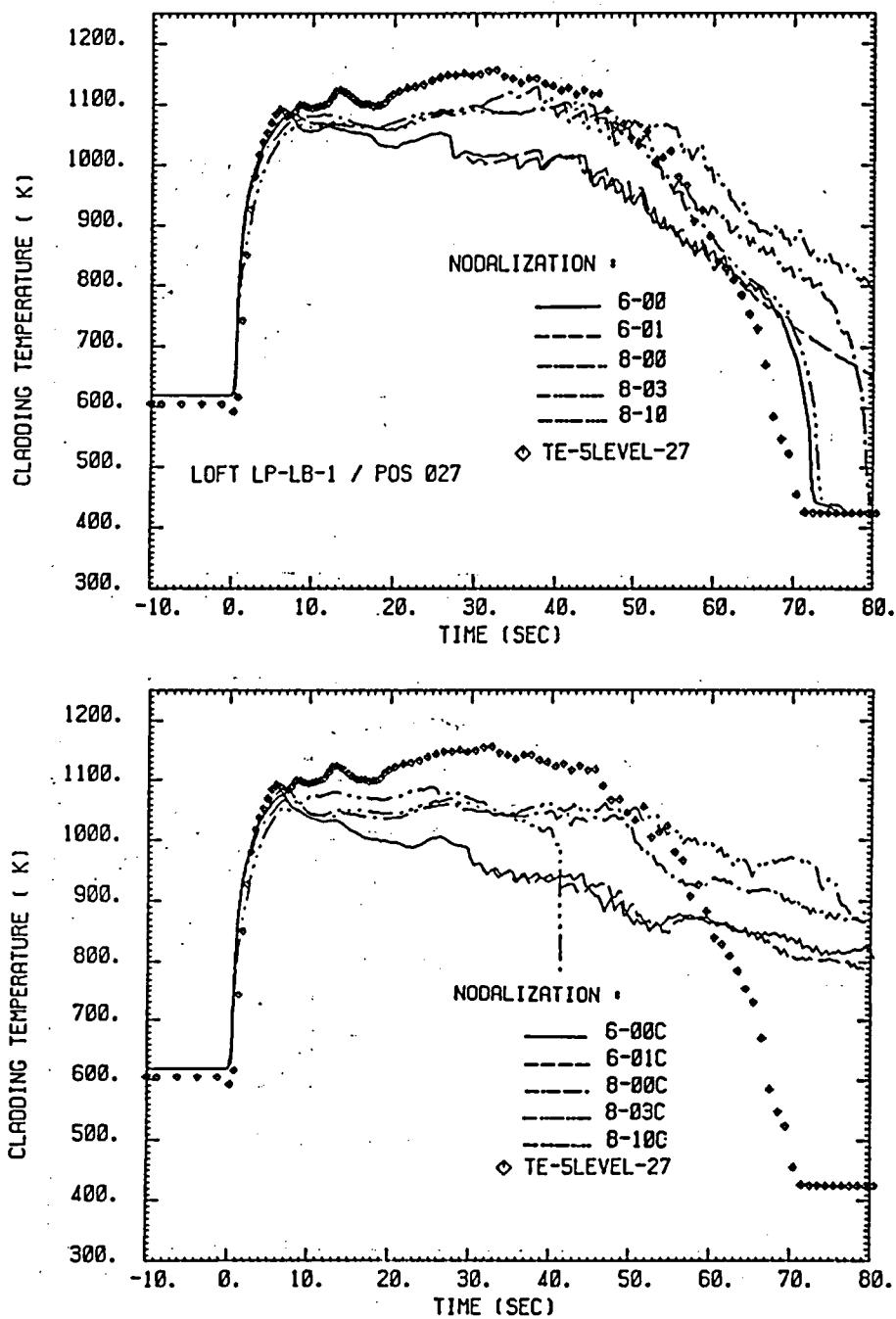


Figure 3.9: Hot-channel cladding temperatures vs. time at axial level 27
compared with the equivalent reference temperature

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

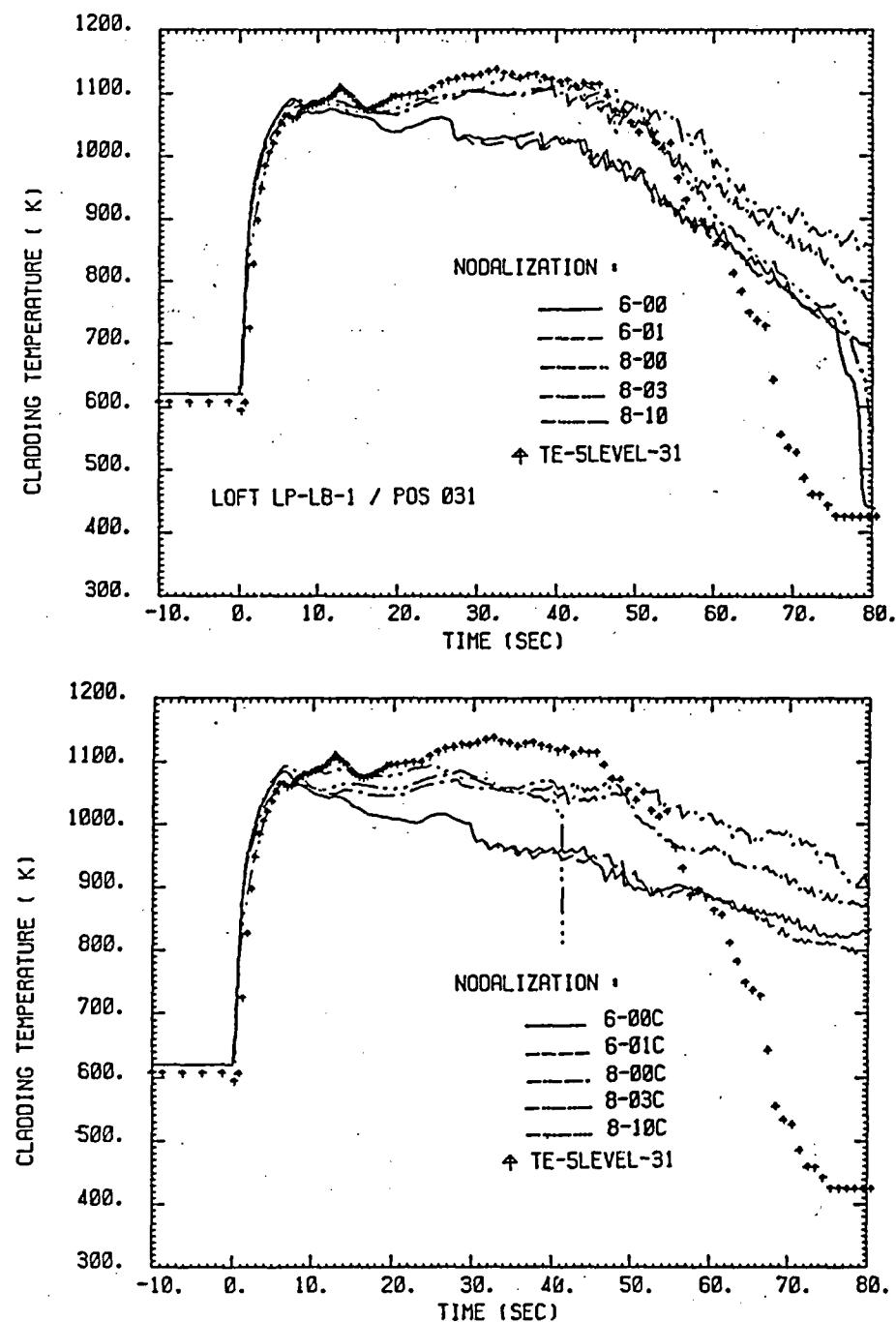


Figure 3.10: Hot-channel cladding temperatures vs. time at axial level 31
compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

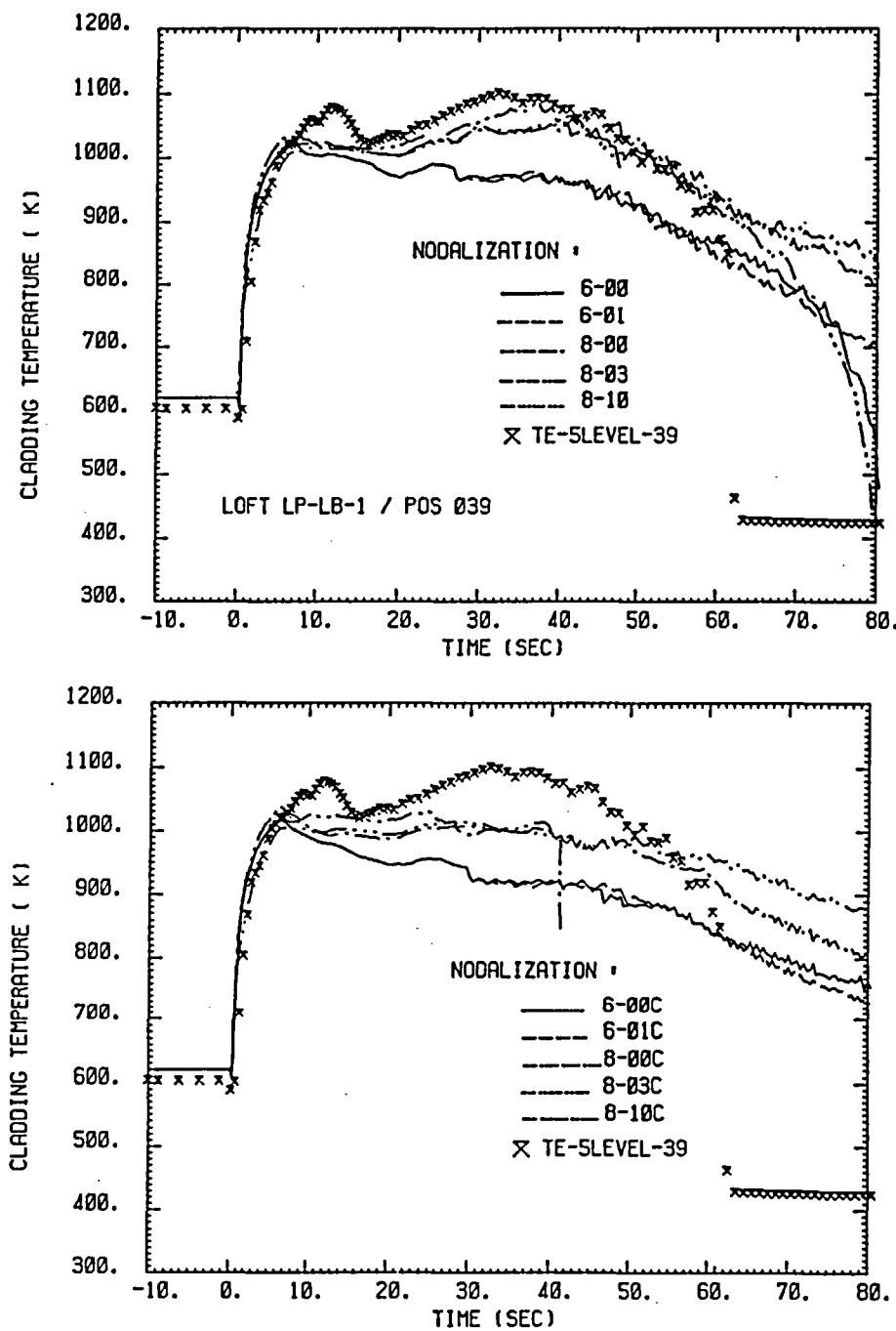


Figure 3.11: Hot-channel cladding temperatures vs. time at axial level 39
compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

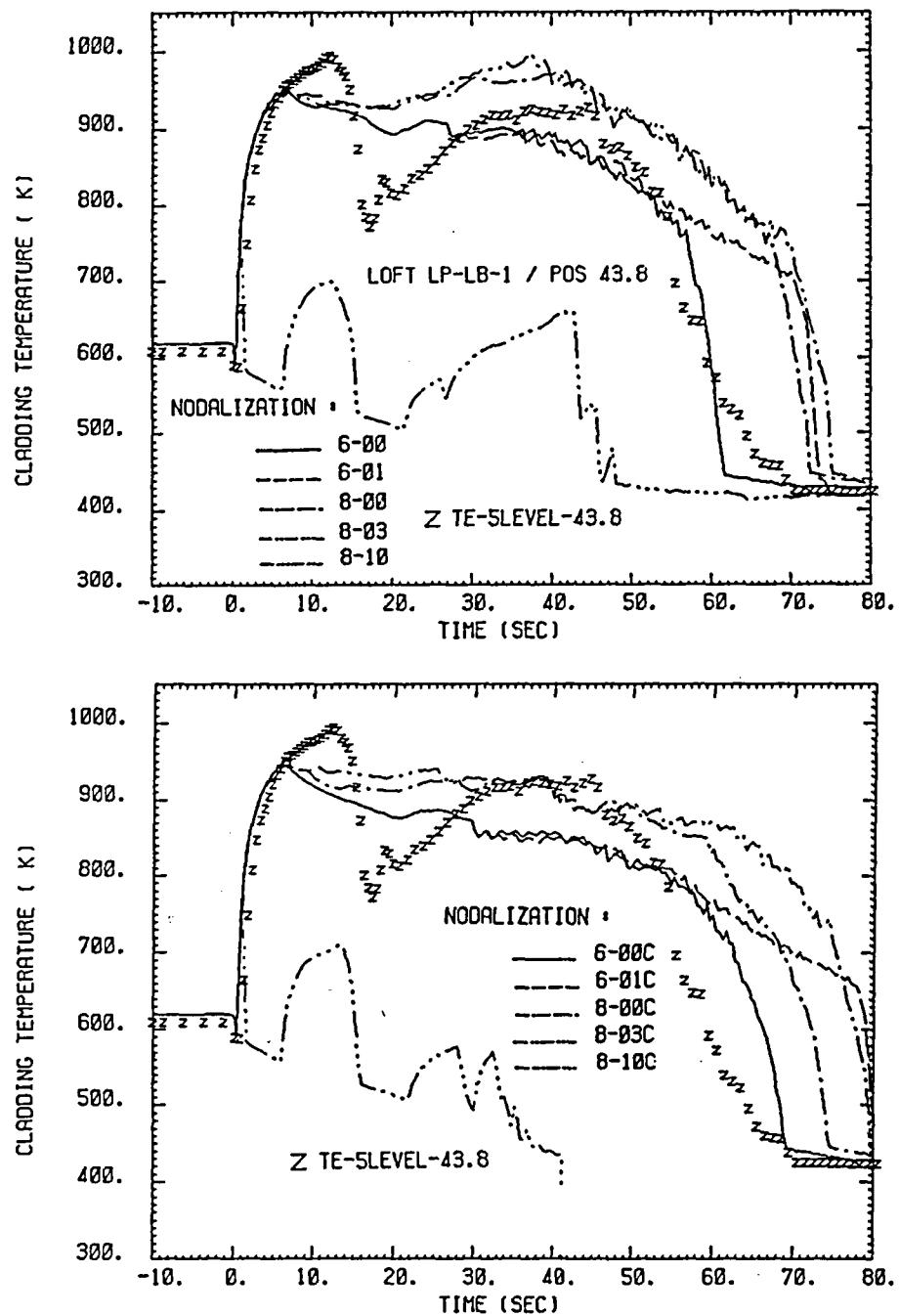


Figure 3.12: Hot-channel cladd. temperatures vs. time at axial level 43.8
 compared with the equivalent reference temperature
 a) by neglecting wall heat capacity
 b) by taking into account wall heat capacity ("C")

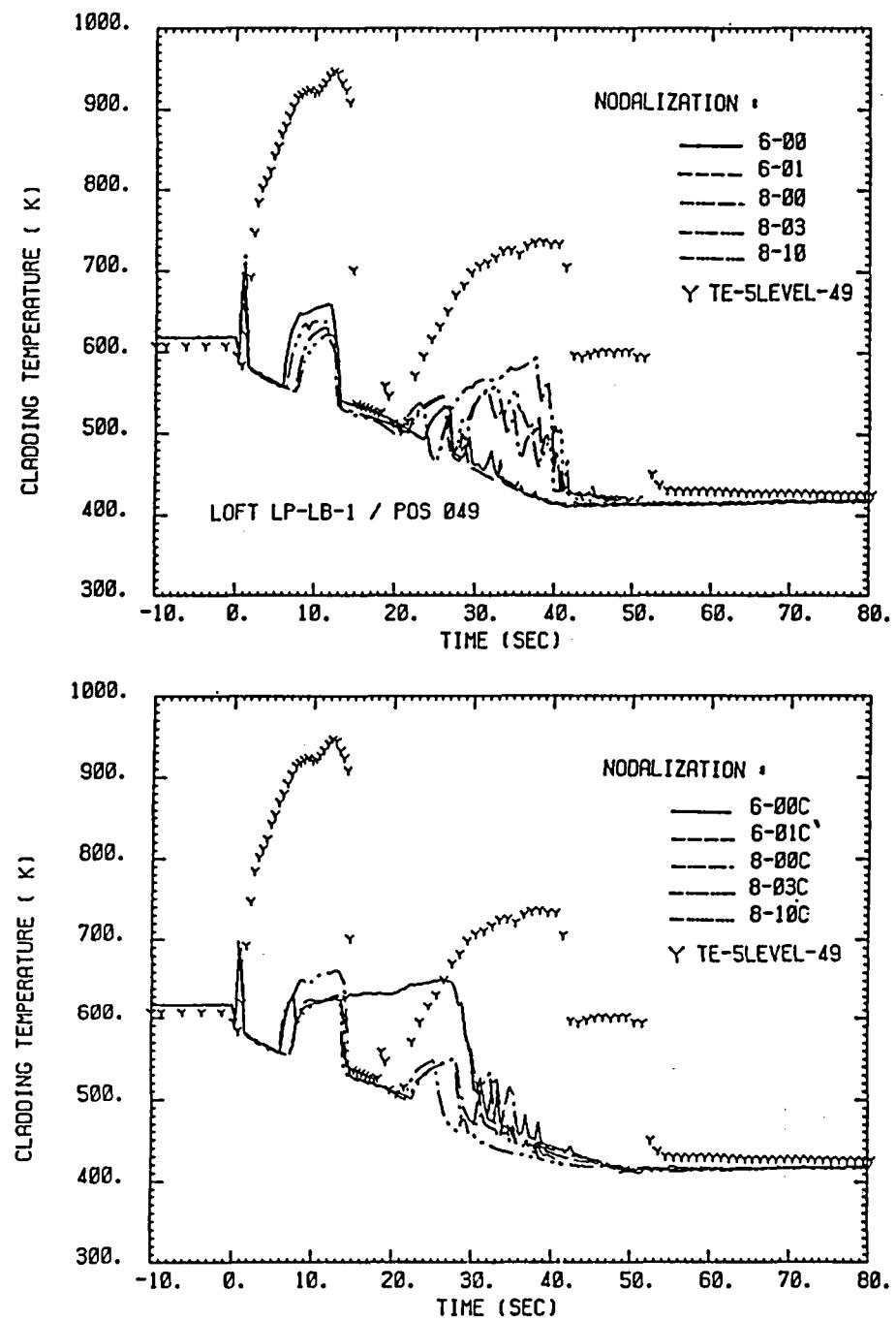


Figure 3.13: Hot-channel cladding temperatures vs. time at axial level 49 compared with the equivalent reference temperature

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

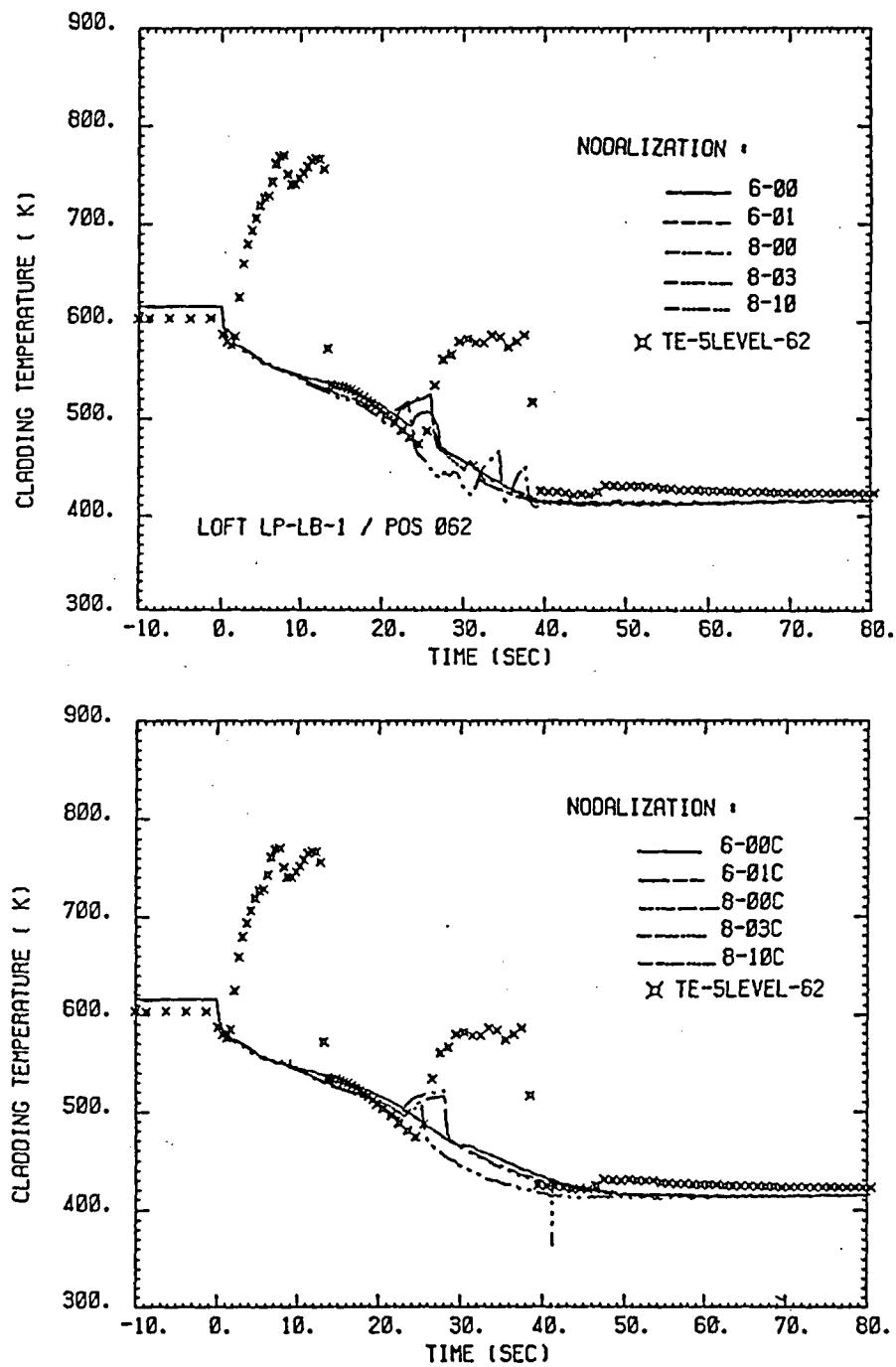


Figure 3.14: Hot-channel cladding temperatures vs. time at axial level 62
 compared with the equivalent reference temperature
 a) by neglecting wall heat capacity
 b) by taking into account wall heat capacity ("C")

LAP5/Mod2 using the 8-10/8-10C nodalizations seems to have other reasons. Whereas at level 43.8, for all the nodalizations except 8-10, RELAP5/Mod2 calculated a drastic increase of the cladding temperature nearly reaching the experimentally inferred values, it totally failed in describing the following temperature drop due to the top-down rewetting (fig. 3.12). The cladding temperature rather stayed at a high temperature level until the QF reached axial level 43.8. The time of final quenching was calculated more or less exact by the 6-00 version; all the other versions of nodalization have overpredicted this time between 12 and 20 seconds.

On axial levels 49 and 62 (figs. 3.13 and 3.14) even the drastic increase of the cladding temperature has not been calculated by RELAP5/Mod2 and only some small temperature spikes have been predicted which not at all give a qualitative right picture of what has happened in this region of the core during the transient. Whereas at level 49, some heat-up cycles have been created by RELAP5/Mod2, the code assumed no heat-up at all for level 62.

Different to this general trend are the calculations of RELAP5/Mod2 using nodalizations 8-10 and 8-10C. Here, the "hydraulic nodalization" is identical to the 8-00 nodalization, but the modelling of the fuel rods differs significantly, namely, the number of radial meshes has been reduced from 10 to 5 radial nodes in the hot rod (one cladding, one gap and 2 fuel zones). Obviously and as long as the cladding temperatures are concerned, these simplifications have a severe influence on the predicting capabilities of RELAP5/Mod2 in the upper part of the LOFT core for a large break experiment like LP-LB-1.

Cladding Temperatures in Side Box 4 (Average Channel)

In figs. 3.15 to 3.18, the time traces of the cladding temperatures at four different core heights in the side box 4 as calculated by RELAP5/Mod2 for the "average channel" have been compared to an average temperature at the specific core height (if the reference is indicated by the word "level") or to one single thermocouple signal (if a specific number is given as reference, e.g. 4G14). Again, for the four axial positions, located 11, 21, 28 and 39 inches from the bottom of the core, two plots are given showing the comparison of the normal (plot a) and the "C" type of nodalizations (plot b).

RELAP5/Mod2 was not successfull in calculating the time behaviour of the cladding temperatures at the four different axial levels either qualitatively or quantitatively. Instead of describing a significant core heat-up followed by a steep temperature drop and a second heat-up to lower peak values, it has predicted a more or less instantaneous core heat-up for levels 11 and 21 and less pronounced also for levels 28 and 39. The peak values of the temperatures and their time of occurrence are not at all comparable to the experimental data. Furthermore, the discrepancies between the results of the different nodalizations were found to be high.

Summarizing Remarks on the Cladding Temperature Calculations

Summarizing our findings with respect to RELAP5/Mod2 -calculations of the cladding temperatures in both the hot and the average channels one has to conclude that:

- in the lower and upper parts of the hot zone of the core (less 15 inches or higher than 45 inches from the bottom of the

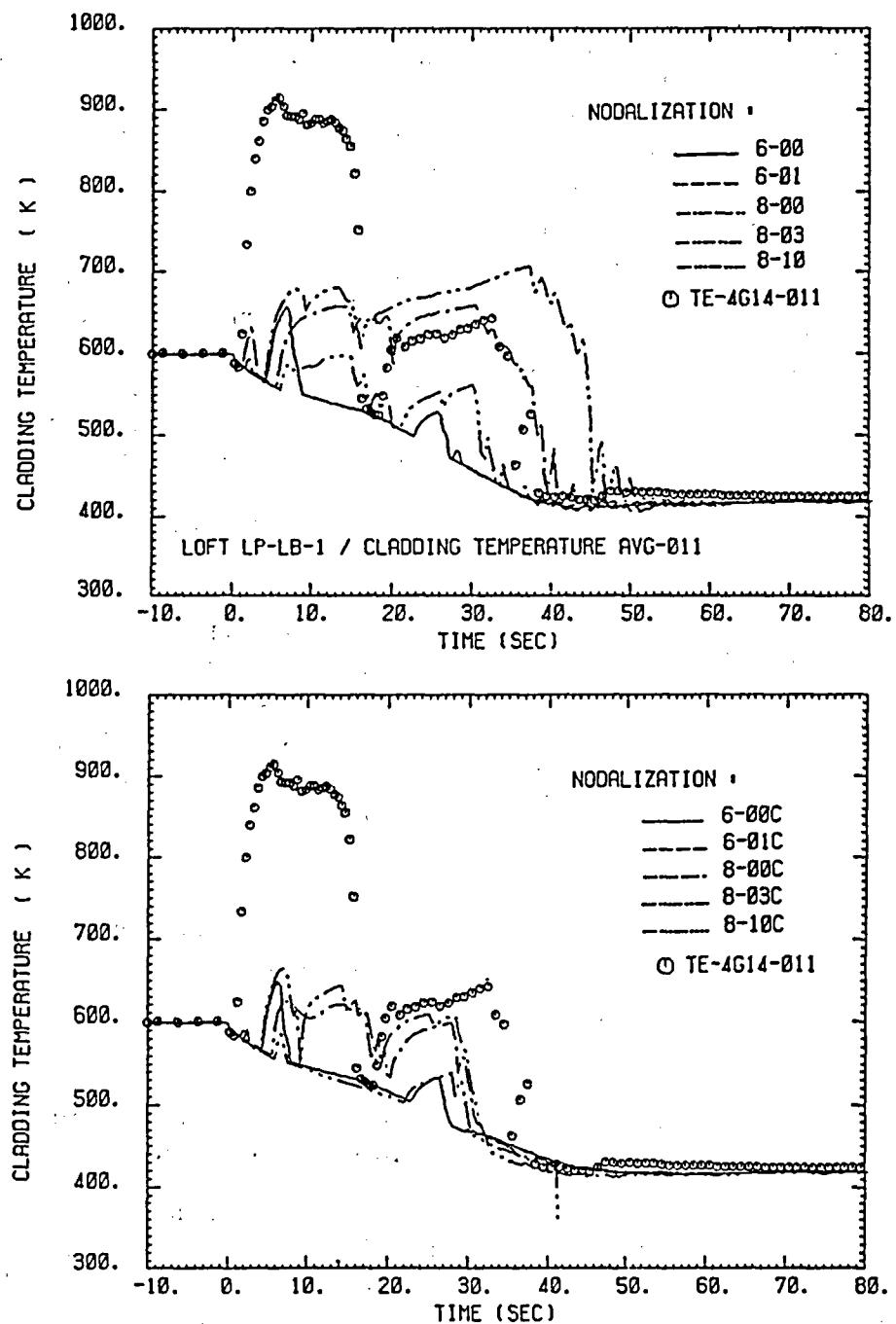


Figure 3.15: Average channel cladding temperatures vs. time at axial level 11
compared with the equivalent reference temperature
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

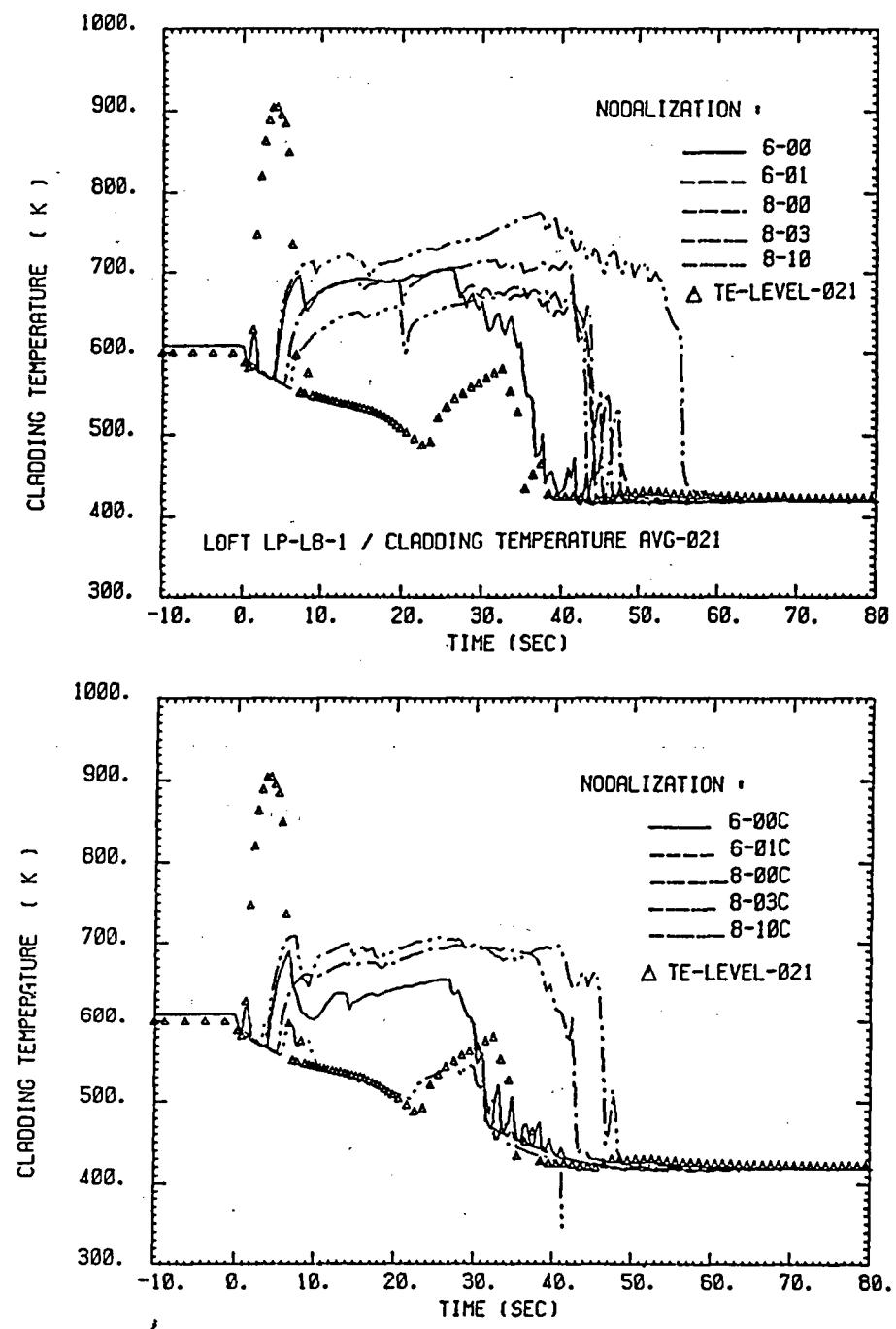


Figure 3.16: Averaged channel cladding temperatures vs. time at axial level 21 compared with the equivalent reference temperature

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

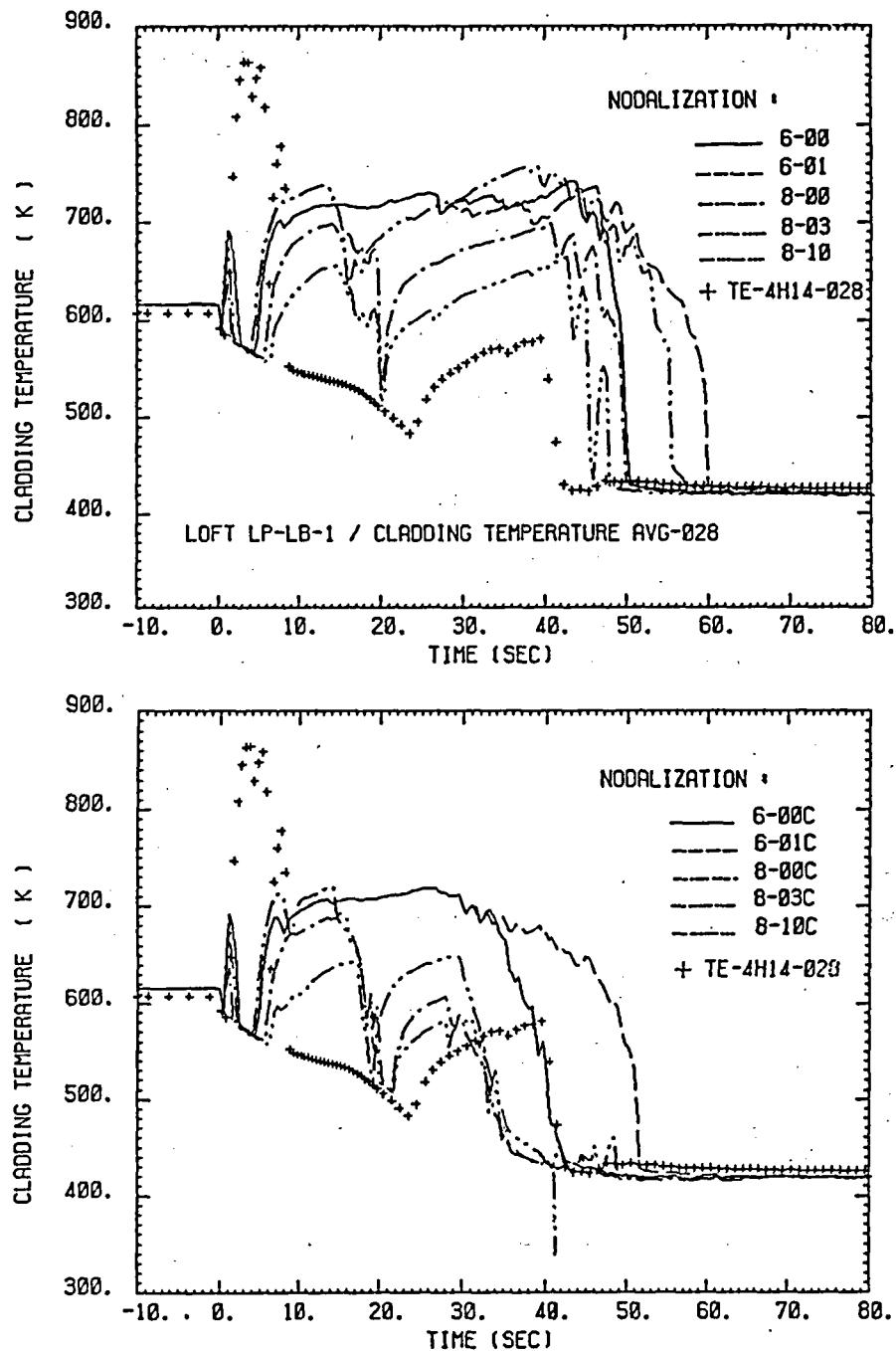


Figure 3.17: Averaged channel cladding temperatures vs. time at axial level 28 compared with the equivalent reference temperature

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

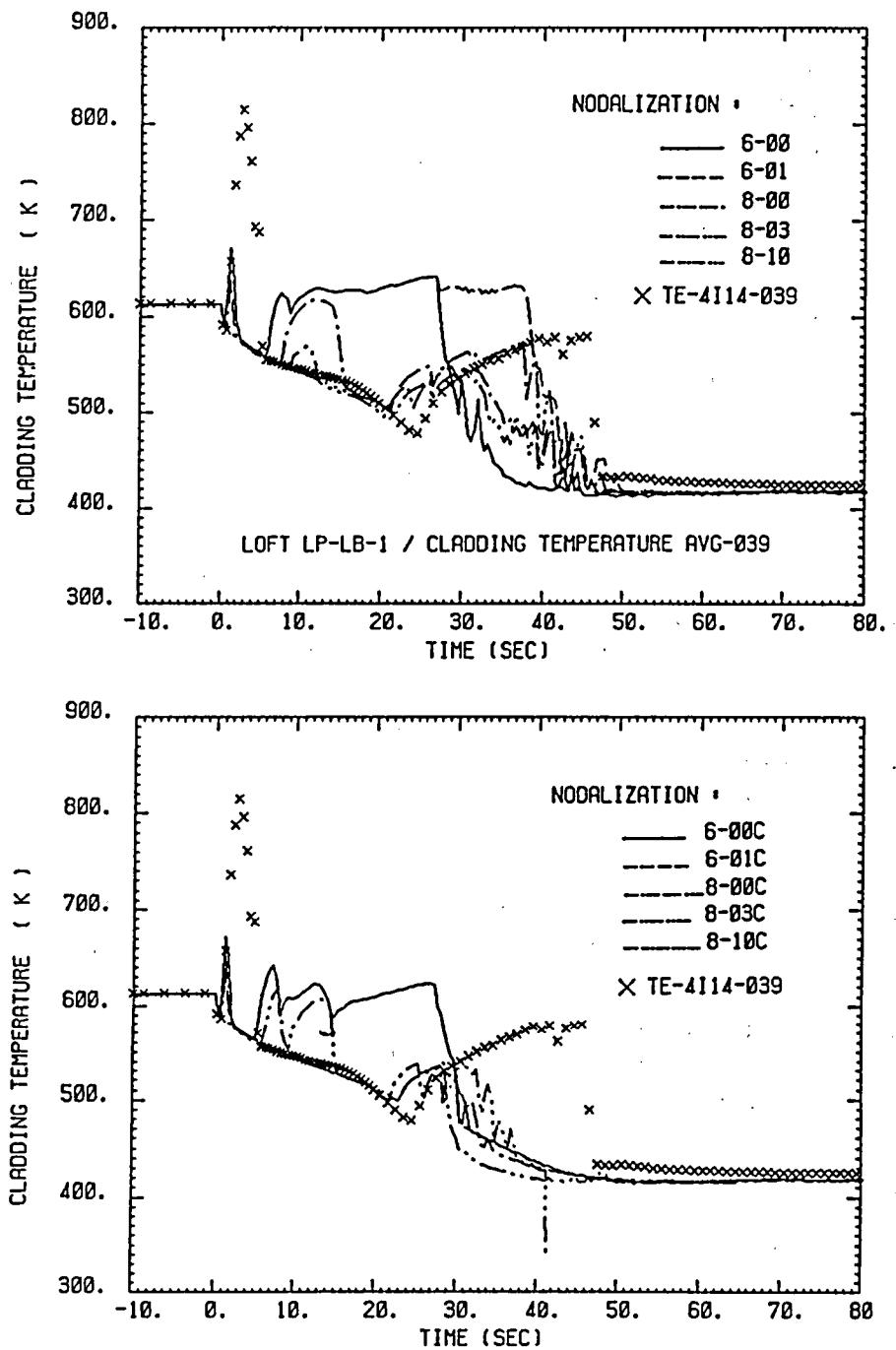


Figure 3.18: Averaged channel cladding temperatures vs. time at axial level 39 compared with the equivalent reference temperature

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

core) as well as in the average channel, RELAP5/Mod2 was not successful in describing the time behaviour of the cladding temperatures either qualitatively or quantitatively.

- in the center part of the hot zone of the core, RELAP5/Mod2 calculated the time behaviour of the cladding temperature qualitatively but underpredicted the temperature level between 50 and 200 degrees.
- generally, the time of final quenching has been overpredicted by RELAP5/Mod2. In the hot channel, these overpredictions are usually higher for the "C"-versions of nodalization; for the average channel, the opposite is the case.
- RELAP5/Mod2 has calculated the peak cladding temperature at axial level 31, i.e. 31 inches from the bottom of the core, whereas the experimentally inferred hotspot is located at level-24.

The reasons for the deviations are multiple. Concerning the axial shift of the hot spot (third item), one of the reasons may be an incorrect assumption of the axial power distribution in the LOFT core; as mentioned in section 2.1, we have used the one published by [5].

For investigating on this problem, the axial distributions of the cladding temperatures in the hot channel as calculated by RELAP5/Mod2 using all the "non-C" types of nodalization have been compared to the equivalent experimental data for four different time points of the transient, namely at -1.2 seconds (i.e. the stationary part of the transient), at 5.3 seconds (blowdown phase), at 20.5 seconds (intermediate phase, start of refill) and at 70.5 seconds, i.e. during the reflood phase (figs. 3.19 a to d).

In fig. 3.19a, the comparison was made for the stationary phase of experiment LP-LB-1. All RELAP5/Mod2 calculations indicated very similar axial distributions of the cladding temperatures which only in the middle and in the upper part of the core (core heights .6 to 1.6) are close to the experimental data (circles in the plot) whereas they differ at the bottom about 40 K. In fact, the experimentally inferred axial cladding temperature distributions have been found to be much more varying than the one calculated by RELAP5/Mod2. One of the reasons may be the fact that RELAP5/Mod2 neglects the axial heat conduction in the cladding as well as in the fuel thus preventing from smoothing out steep axial temperature gradient in the cladding and the fuel (axial conduction is only considered by RELAP5/Mod2 near the quench front when the reflood model is applied). On the other hand, if a change in the axial power distribution would bring any improvements is an open question and has not been tested yet.

During the blowdown interval, i.e. 5.3 seconds after the initiation of the transient (fig. 3.19b), the axial cladding temperature distributions as calculated by RELAP5/Mod2 using different nodalization schemes differ quite significantly both to each other as well as in comparison to the experimental findings. The calculated peak cladding temperatures are centered around 0.75m whereas the corresponding experimental values (triangles) have been found at approximately 0.55m. On top of this, the RELAP5/Mod2 calculated core heat-ups were rather concentrated in the center region of the core (0.4 to 1.2m) whereas the experimental data indicated a more widened core heat up. Again, one of the reasons may be the neglection of axial heat conduction in the cladding as well as in the fuel by the code.

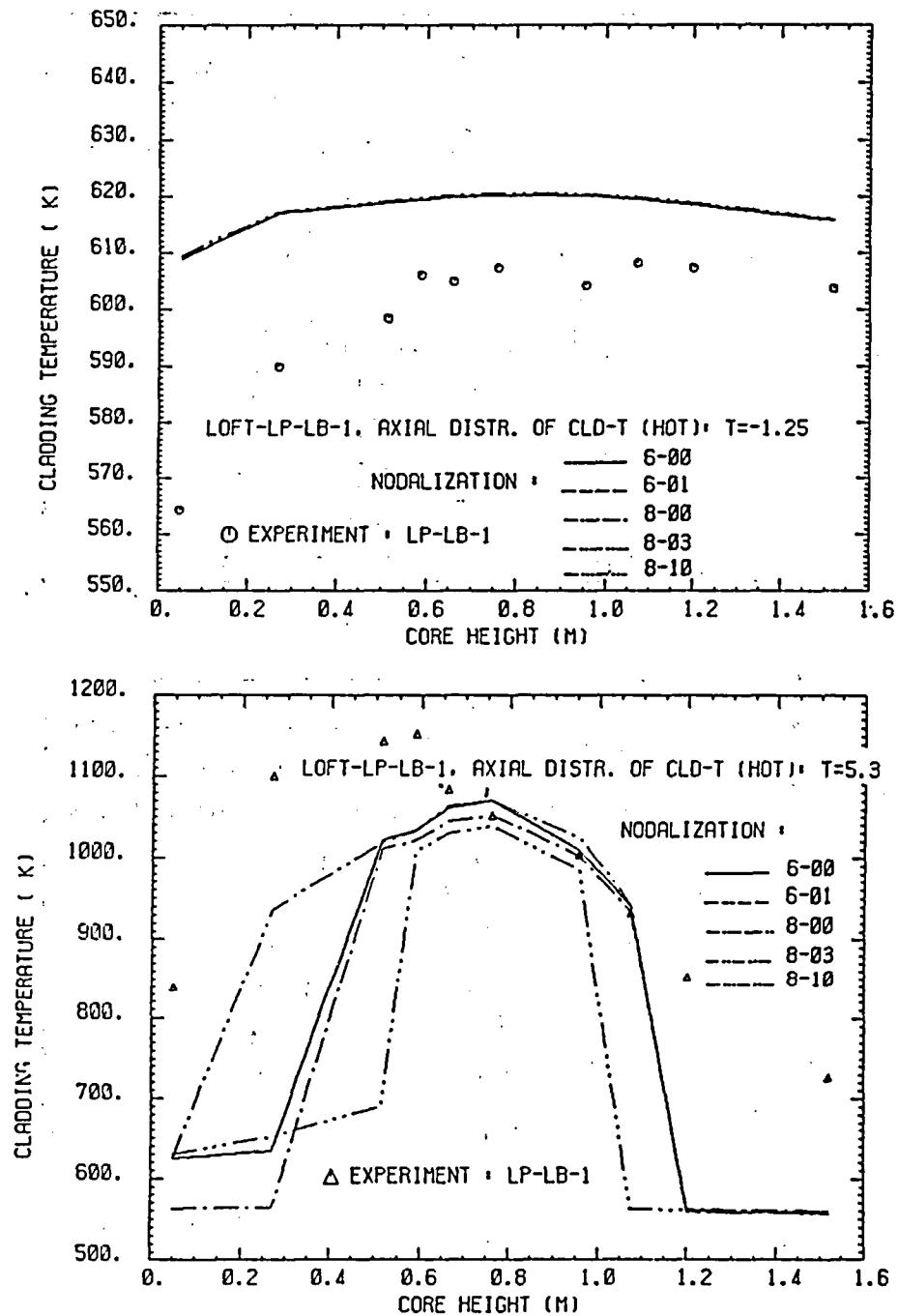


Figure 3.19: Axial cladding temperature distribution in the hot channel compared with the equivalent averaged reference temperatures in box 5

- at -1.2 seconds (stationary phase)
- at 5.3 seconds (blow-down phase)

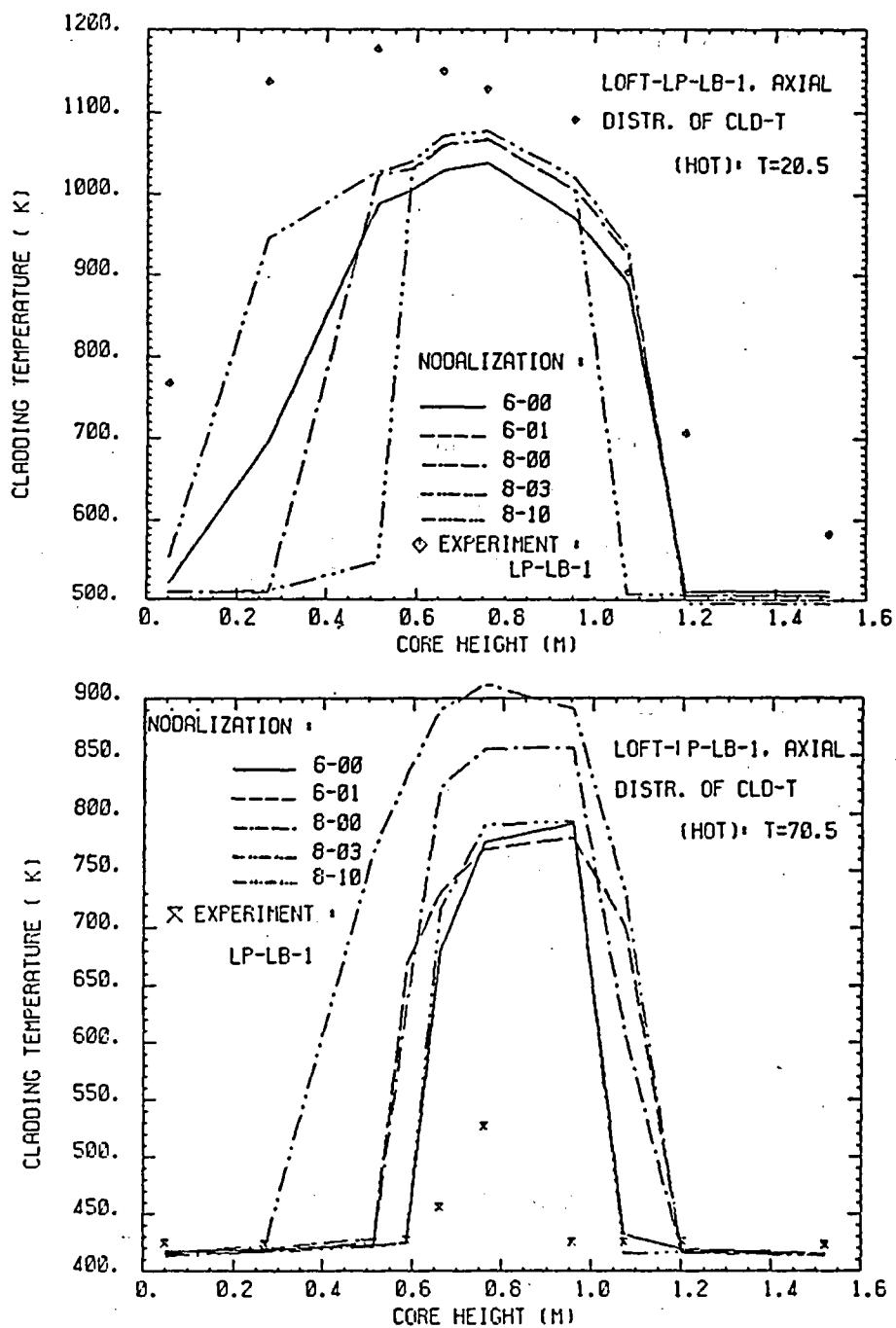


Figure 3.19: Axial cladding temperature distribution in the hot channel compared with the equivalent averaged reference temperatures in box 5
 c) at 20.5 seconds (intermediate phase)
 d) at 70.5 seconds (reflood-down phase)

Closest to the experimental data are the RELAP5/Mod2 calculations based on the 8-03 nodalization, i.e. the most simplified version (-·--- lines).

Things do not change significantly for the two remaining time point of consideration, namely 20.5 seconds (intermediate stage between end of blow-down and beginning of refill) and 70.5 seconds (reflood phase) after the initiation of the transient (figs. 3.19 c and d). Compared to the experimental findings of a heat-up of nearly the whole core with the peak value at 0.6 m, RELAP5/Mod2 still has calculated a core heat up centered to the middle of the core with the peak value at 0.75 m. In contrary to time-point 20.5s, where RELAP5/Mod2 still has underpredicted the peak cladding temperatures, at 70.5s RELAP5/Mod2 overpredicted the cladding temperatures in the center of the core depending on the chosen nodalization between 250K and 400 K; but these overpredictions have to be attributed to errors in the calculation of the time of final quenching which usually has been overpredicted 10 to at least 25 seconds (from the codes point of view, parts of the rods are still in high temperature conditions whereas in the experiment, they already have been quenched at this time).

Void Fraction, Flow Regime and Heat Transfer Coefficients in the Core Zone

Besides the heat generation in the fuel (source), the other important quantity influencing the cladding temperature is the heat transfer from the cladding to the surrounding fluid (sink). To find some reasons for the deviations of the time traces of the cladding temperatures for different nodalizations, one has to investigate the heat transfer to the fluid at the specific nodes for these different nodalizations even no experimental reference

is available.

The heat transfer, expressed by the heat transfer coefficient (HTC), is depending on the mass flow, the local void fraction and the flow-regime "assumed" by RELAP5/Mod2 which itself mainly refers to the local void fraction as well as to the mass flow and the system pressure. Consequently, erroneous mass flows and void fraction distributions will lead to wrong heat transfer coefficients and finally to questionable predictions of the cladding temperatures.

In Figs. 3.20 to 3.27 from top to bottom the local void fractions, the flow regimes as chosen by RELAP5/Mod2 and the heat transfer coefficients have been plotted versus time for axial levels 27 inches (figs. 3.20 to 3.23) and 43.8 inches from the bottom of the core (fig. 3.24 to 3.27). The comparison has been made for four versions of nodalizations, namely 6-00, 6-01 (most detailed), 8-10 (medium simplified) and 8-03 (most simplified).

For all four types of nodalizations, the time behaviour of the local void fraction at the equivalent axial level seem to be comparable, although the decrease for times higher than 70 seconds is more pronounced for the 6-01 and 8-10 versions. After the initiation of the transient, the void fraction has increased very rapidly from zero to nearly 100%, where it remained until refilling has reached the level under investigation. Then the void fraction remained quite unstable for another 10 to 20 seconds, where the oscillations of the void fraction nearly covered half of its range. With regard to these oscillations, the most simplified 8-03 versions of nodalization (more simplified with respect to the outer primary system and not to the core region which remained unchanged for all the different nodalizations) seems not to be more unstable than the most detailed versions 6-00 and 6-01. But

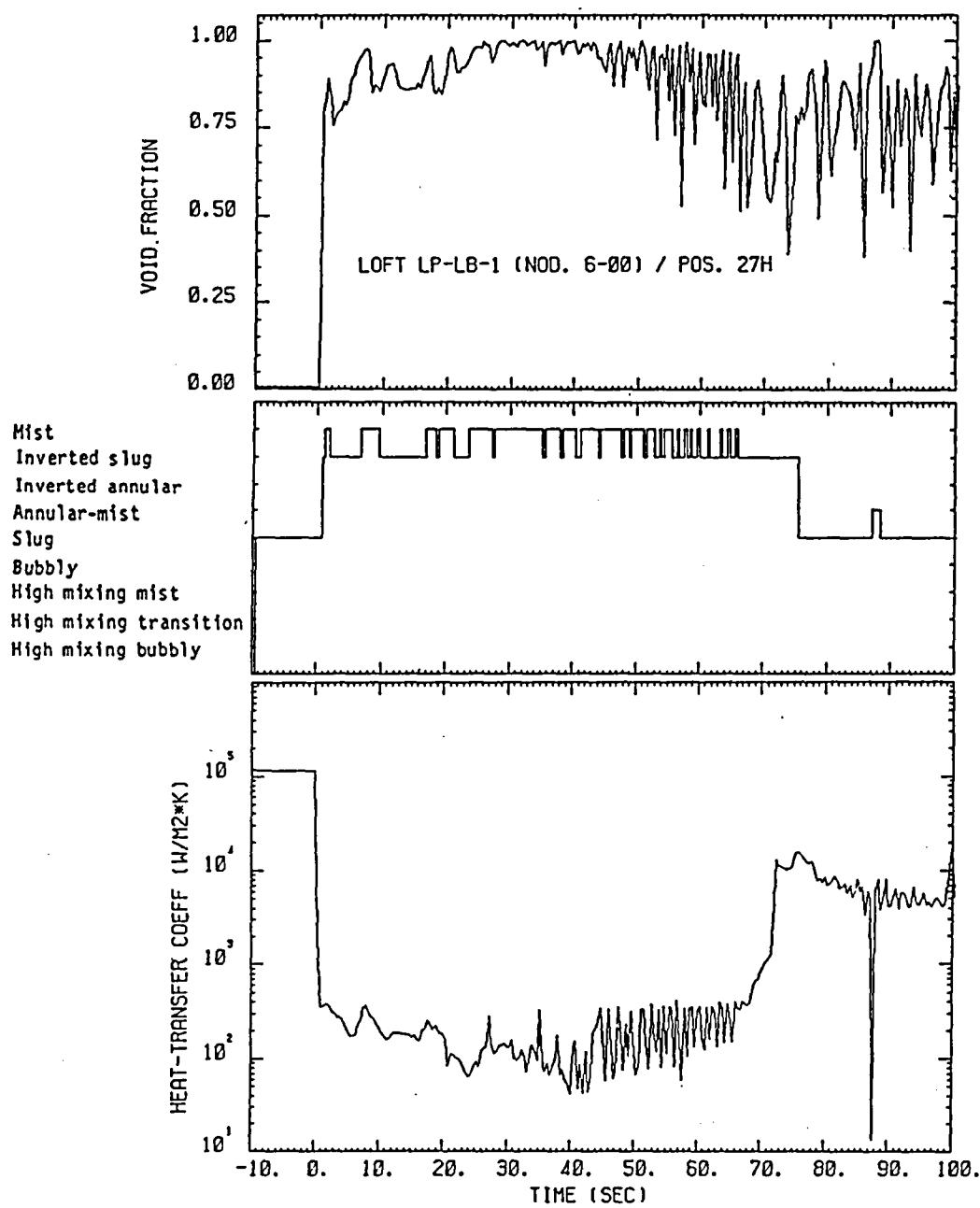


Figure 3.20: Calculated void fraction, flow regime and HTC (nodalization 6-00) for level-27 in the hot channel

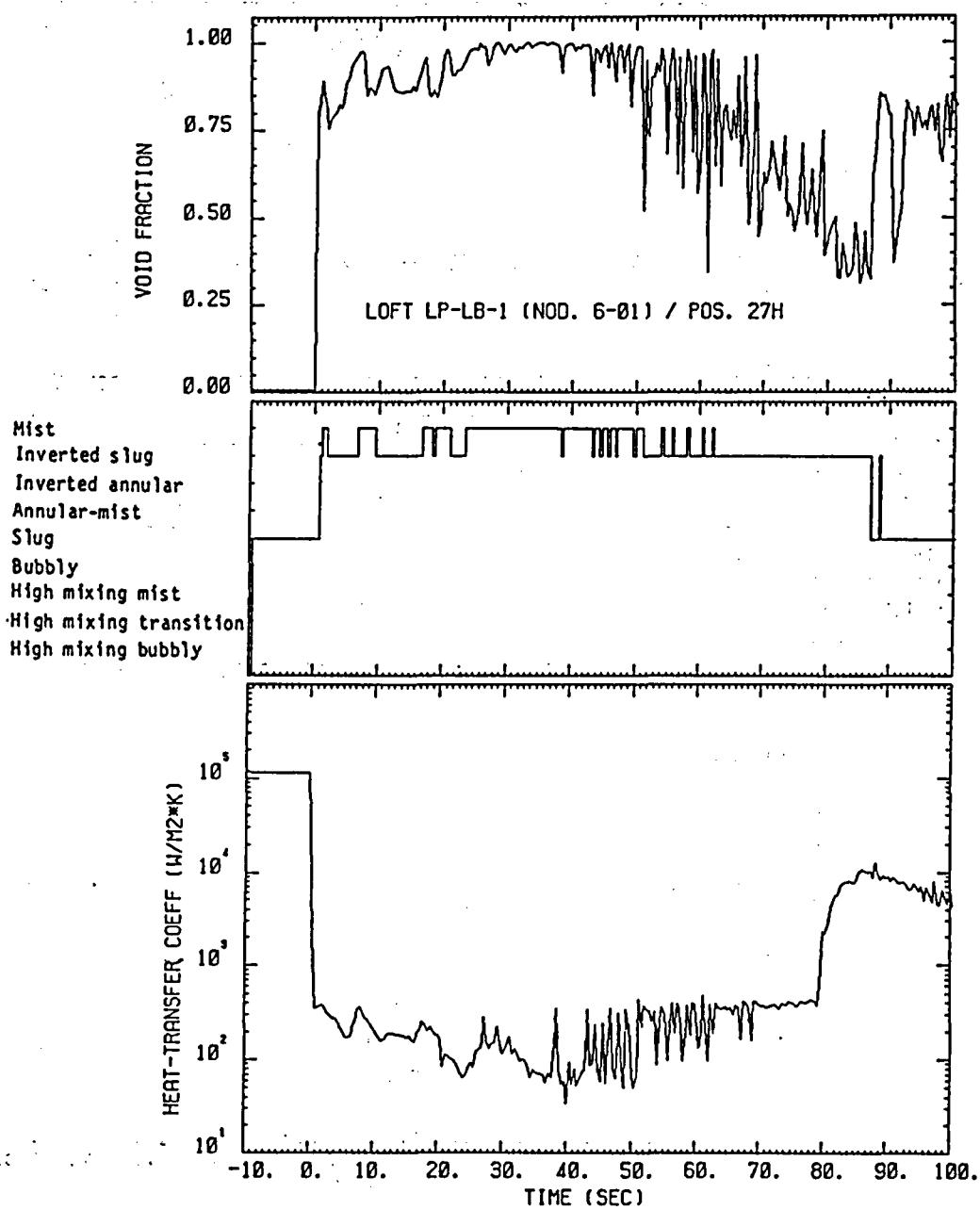


Figure 3.21: Calculated void fraction, flow regime and HTC (nodalization 6-01) for level-27 in the hot channel

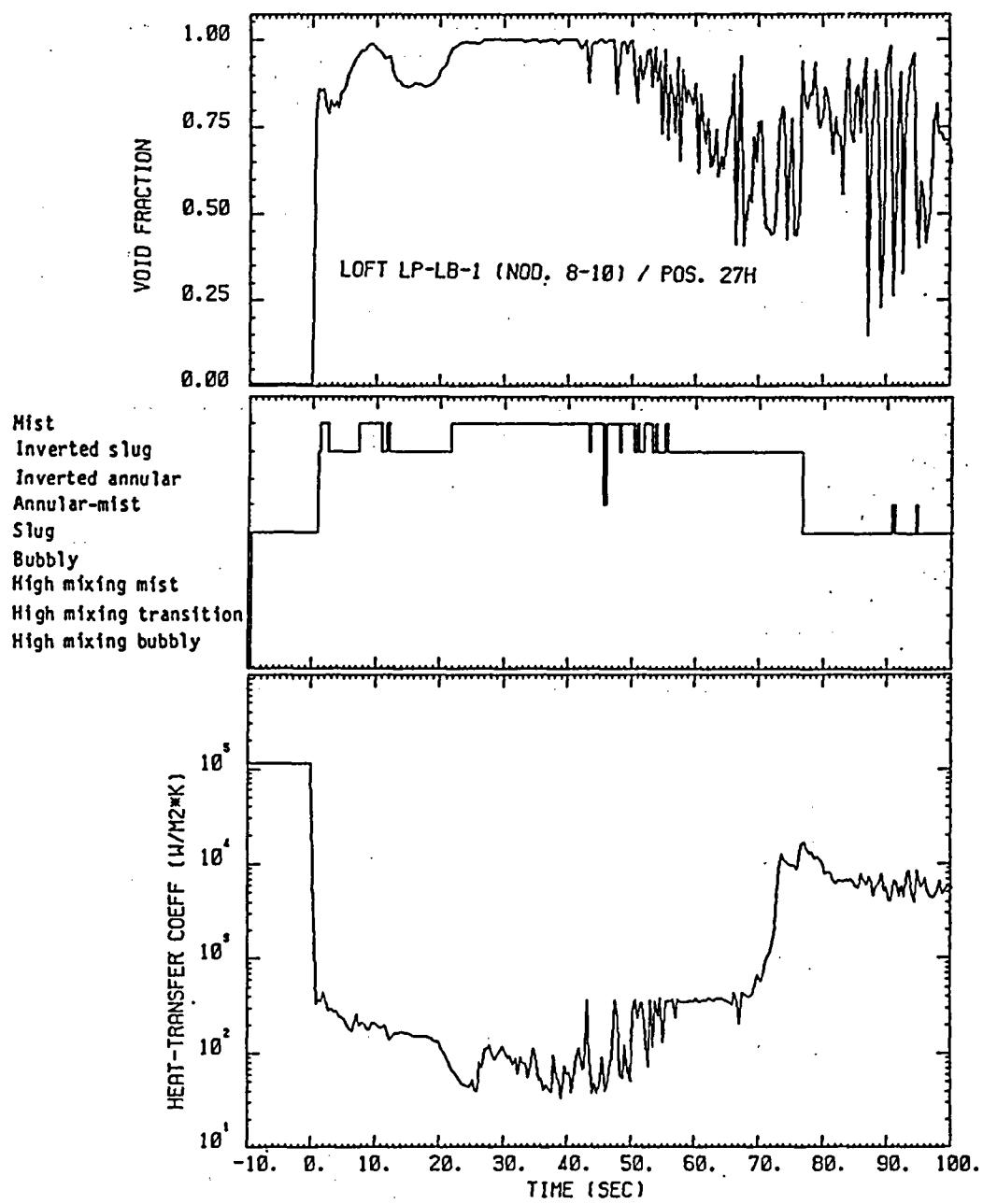


Figure 3.22: Calculated void fraction, flow regime and HTC (nodalization 8-10) for level-27 in the hot channel

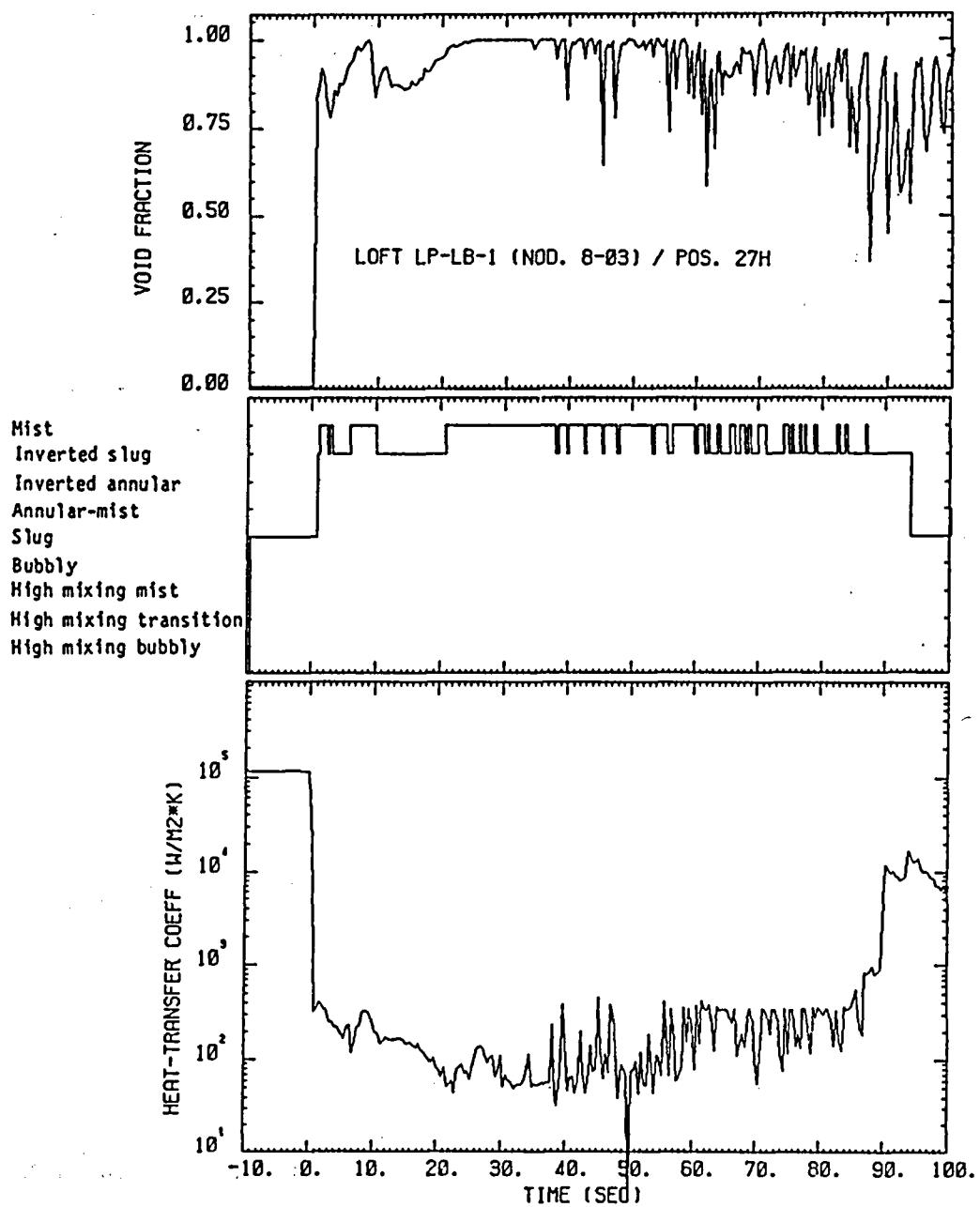


Figure 3.23: Calculated void fraction, flow regime and HTC (nodalization 8-03) for level-27 in the hot channel

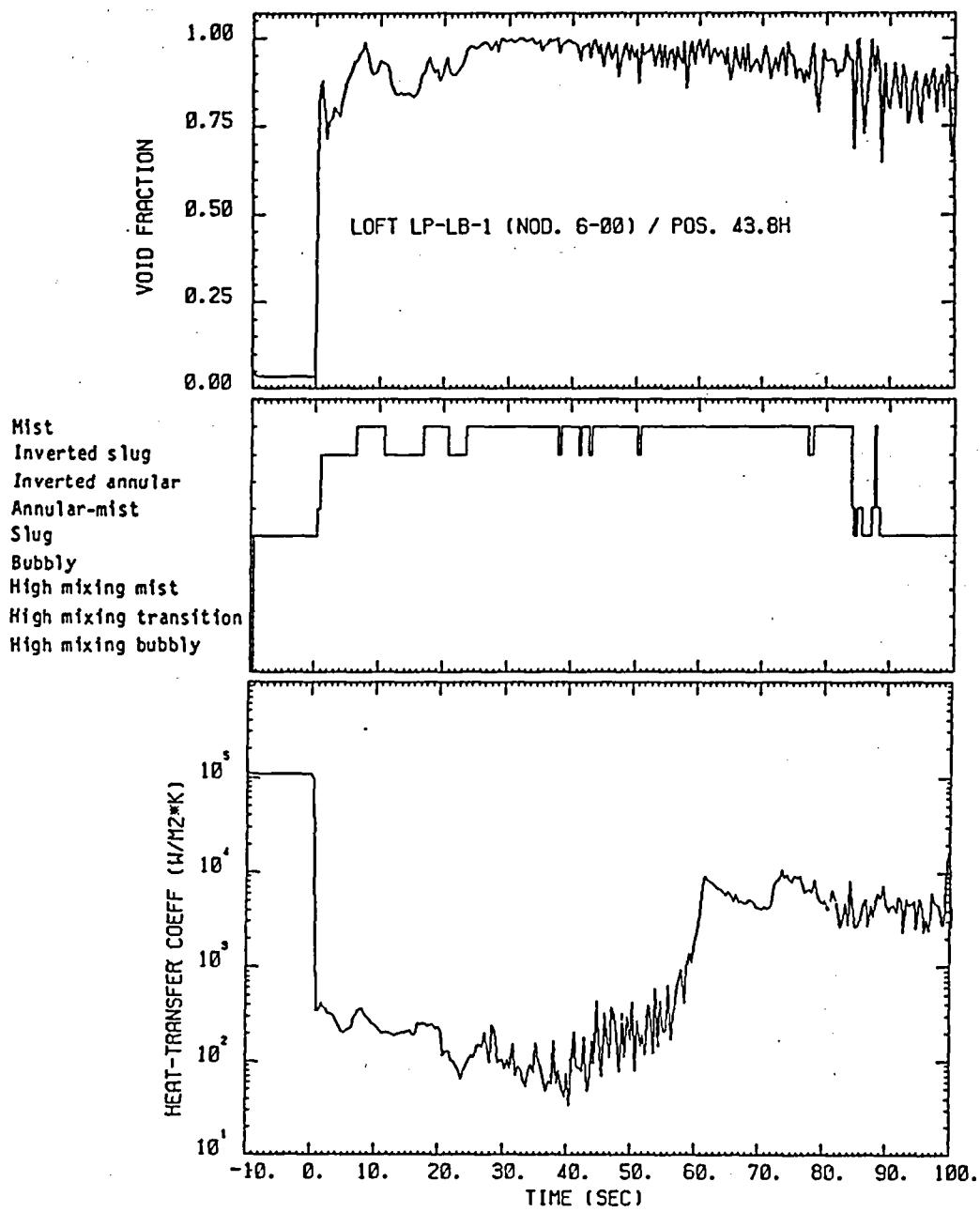


Figure 3.24: Calculated void fraction, flow regime and HTC (nodalization 6-00) for level-43.8 in the hot channel

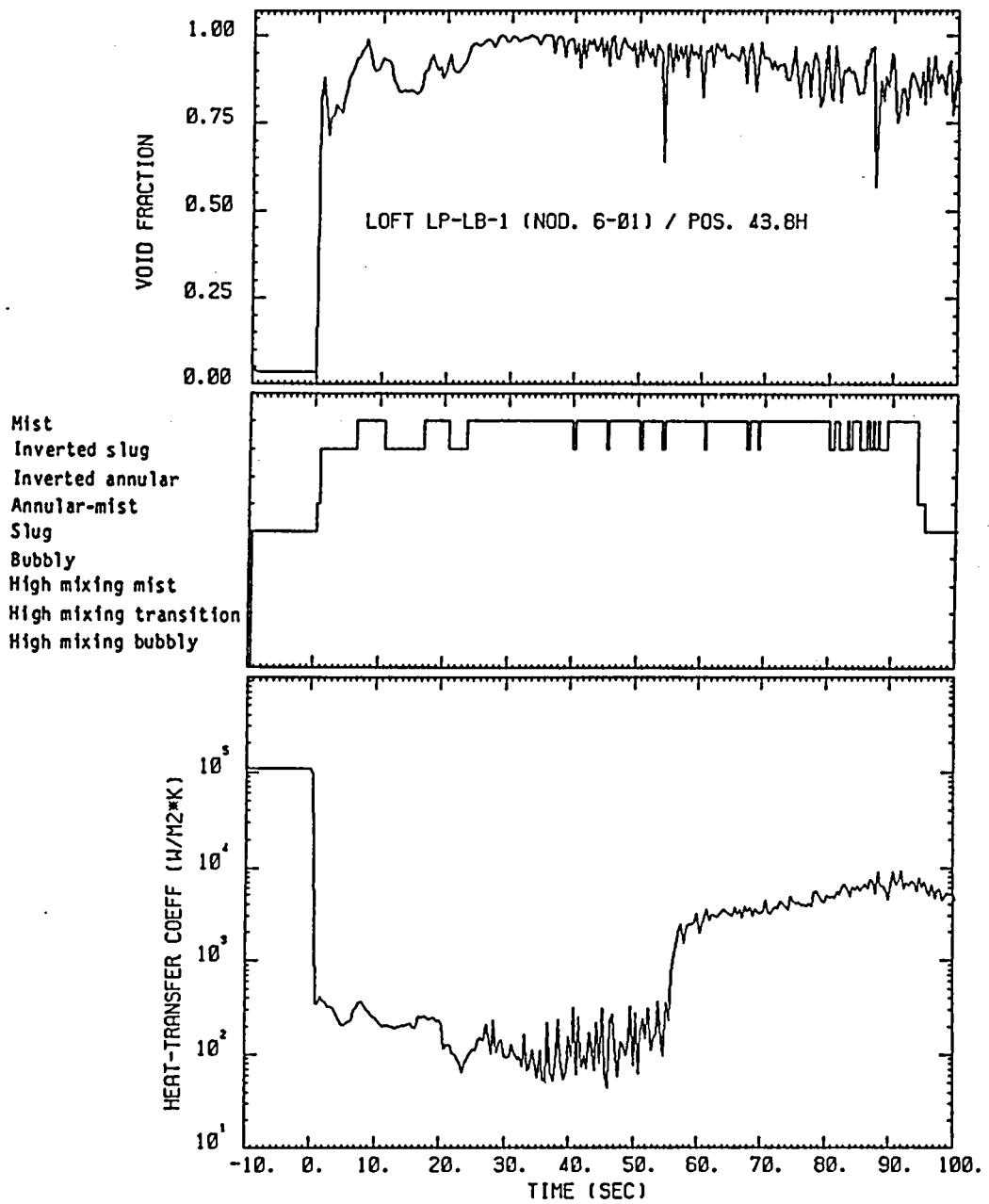


Figure 3.25: Calculated void fraction, flow regime and HTC (nodalization 6-01) for level-43.8 in the hot channel

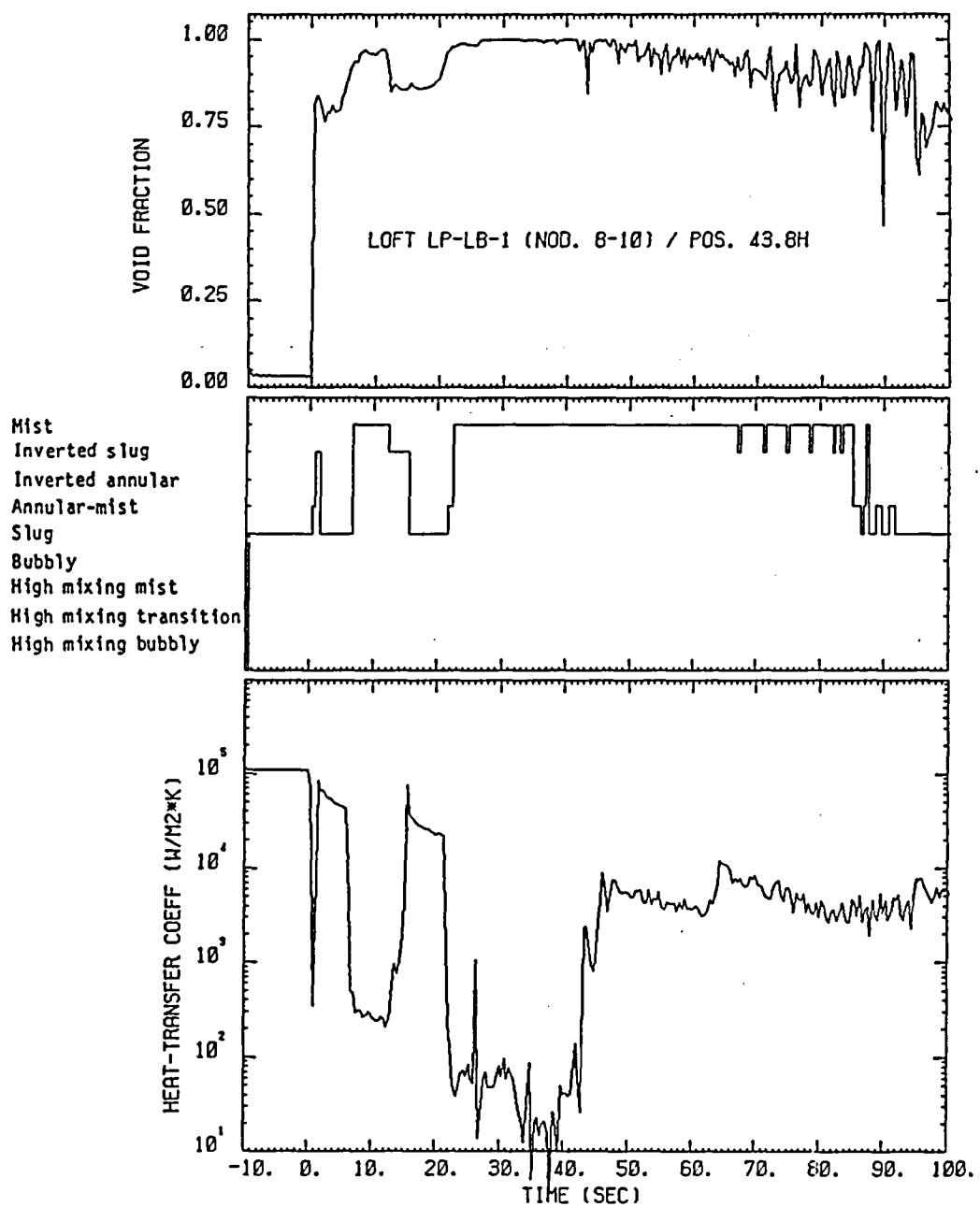


Figure 3.26: Calculated void fraction, flow regime and HTC (nodalization 8-10) for level-43.8 in the hot channel

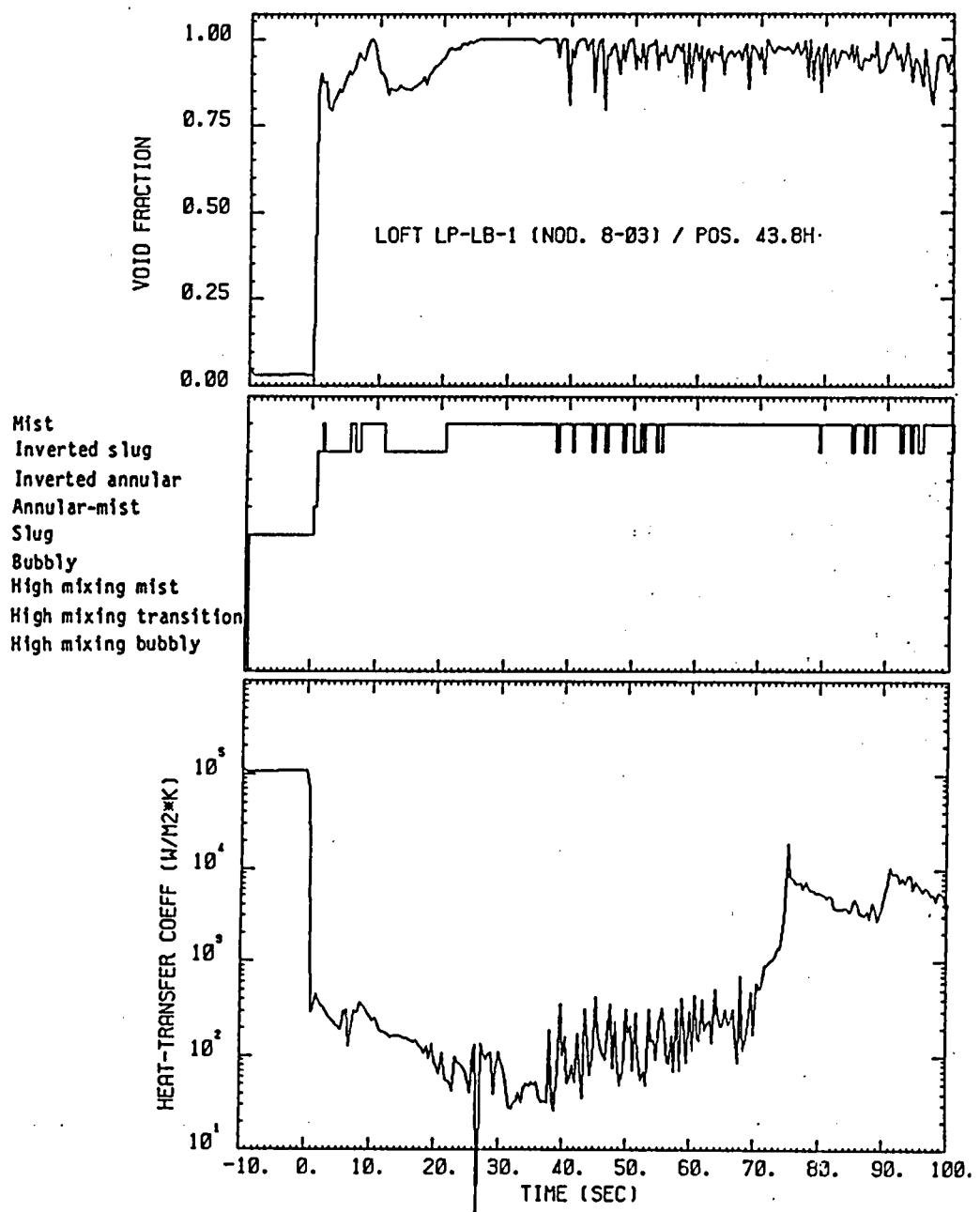


Figure 3.27: Calculated void fraction, flow regime and HTC (nodalization 8-03) for level-43.8 in the hot channel

generally, compared to axial level 27, these oscillations have been found to be significantly smaller at axial level 43.8.

The void fraction is one of the main parameters of RELAP5/Mod2 to determine the flow regime which itself is a key information for the evaluation of the interfacial heat transfer as well as of the interfacial shear stress coefficient which, to close the circle, again highly influences the void fraction distribution. Therefore, the graphs in the center of figs. 3.20 to 3.27 show the flow regimes, as defined by the code, as a function of time. In the stationary phase of the experiment, RELAP5/Mod2 decided for slug-flow in the hot zone of the core. After the initiation of the transient, it decided for inverted slug-flow or alternatively mist-flow until the occurrence of the quench at the level under investigation. Then again, slug-flow has been assumed alternatively with annular-mist-flow. Depending on the nodalization used for the calculation, a smaller or even greater number of "switches" between inverted slug and mist-flow on one side and between slug and annular-mist-flow on the other side may occur. The differences of the latter two flow regimes are minor important for the determination of the heat-transfer-coefficient (HTC) from the wall to the liquid but may result in enormous differences when evaluating the interfacial friction factors and the interfacial heat transfer coefficients. Probable oscillations in these two important quantities are then feedbacked, causing instabilities in the void fraction calculation.

The lower graphs on figs. 3.20 to 3.27 show the heat-transfer-coefficients (HTC) as a function of time. As expected, heat-transfer-coefficient drops rapidly within the inverted-slug / mist-flow regimes thus resulting in heat-up of the fuel. Occurrence of the rewetting is well indicated by the steep increase of

the heat-transfer-coefficient between 40 and 90 seconds, depending on the axial location and the type of nodalization.

We would like to focus the attention of the reader on some inconsistencies between the flow regime indicator (middle plot) and the heat-transfer-coefficient (lower plot) more or less pronounced in all of the eight calculated cases, namely that the time-traces of the flow regime indicator and of the heat-transfer-coefficient indicate "quench" at different times. Whereas at axial level 27 (figs. 3.20 to 3.23), this discrepancy is only a few seconds (the "quench time" of the heat-transfer coefficient is comparable to the value given by the steep negative gradient of the cladding temperature, see fig. 3.9), at axial level 43.8 (figs. 3.24 to 3.27) this difference is raised up to 40 seconds, slightly depending on the nodalization (again, the heat-transfer-coefficient "quench" is comparable to the cladding temperature "quench" on fig. 3.12). In other words, for longer periods, RELAP5/Mod2 calculated the heat-transfer-coefficient from the cladding to the coolant assuming completely other flow conditions than the heat-transfer-coefficient between the steam and liquid phases.

As we have already mentioned above, flow regime and heat transfer coefficients in the core region are strongly depending on the axial void fraction distribution as well as on the mass flows in the core region. Both of them are determined by the thermohydraulic conditions in the primary system of the LOFT reactor like the intact and broken loops, the pressurizer, the heat sink (steam generator secondary side or a more simplified version of it), the primary coolant pumps and the behaviour of the ECC-systems. The predictions of their behaviour during the transient de-

pend on the ability of the code in describing the sequence of thermohydraulic phenomena. Therefore, a realistic description of the main phenomena has to be regarded as a "conditio sine qua non" for the predicting capability of the key parameters like the cladding temperatures.

In what follows, we shall concentrate on the description of these phenomena by considering some other important parameters. But before we start this discussion, we would like to look also at the second key parameter, the center fuel temperatures, with respect to safety aspects, which in the case of a large break are of less importance because the reactor has been scrammed within parts of a second after the initiation of the transient, thus drastically reducing the heat generation within the fuel.

3.4.2 Fuel Center Temperatures

Only at two axial levels experimentally inferred fuel center temperatures are available, namely at levels 27 and 43.8 (i.e. 27 inches and 43.8 inches from the bottom of the core). The equivalent predictions of RELAP5/Mod2 for the different nodalization schemes have been compared to the experimental data and plotted in figs. 3.28 and 3.29. The experimental data are average values of fuel center temperature data at 10 radially distributed positions on axial level 27 of the center box 5 and of 5 thermocouples at axial position 43.8.

Obviously, at both levels the highest fuel temperatures have been reached at full power conditions, before the transient has been initiated. For these stationary conditions, the calculated temperatures at both axial levels are quite close to the experimental data, independently of the type of nodalization, al-

though the temperature is approximately 400 K lower at the higher core position.

During the transient, at axial level 27 (fig. 3.28), the calculated fuel center temperatures have been found to be in satisfactorily good agreement with the experimentally inferred reference temperatures both qualitatively and quantitatively and the differences between the results of RELAP5/Mod2 using different nodalizations are quite small.

At level 43.8 (fig. 3.29), the agreement with the experimental data is a little bit worse with respect to the qualitative time behaviour. Probably due to top-down quenching in the upper part of the core, the experimentally inferred center fuel temperature has dropped significantly between 18 and 30 seconds of the transient. This temperature drop has not been calculated by RELAP5/Mod2 because it failed to catch the top-down quench phenomenon as we have already discussed in section 3.4.1. An exceptional behaviour is indicated by the results of the 8-10 / 8-10C calculations. Here, the reduction of the number of radial meshes in the fuel rod has lead to results which totally underestimated the experimentally inferred data.

3.4.3 System Pressures

It is a well-known fact that most of the best-estimate codes do a quite satisfactory job when predicting the system pressures. Our investigation also confirms this common knowledge.

In figs. 3.30a and b, the system pressures as calculated by RELAP5/Mod2 have been compared to the experimental data, i.e. the absolute pressures as measured by the pressure transducer mounted in the cold leg of the intact loop at station PC-002. As usual in this contribution, we again have separated

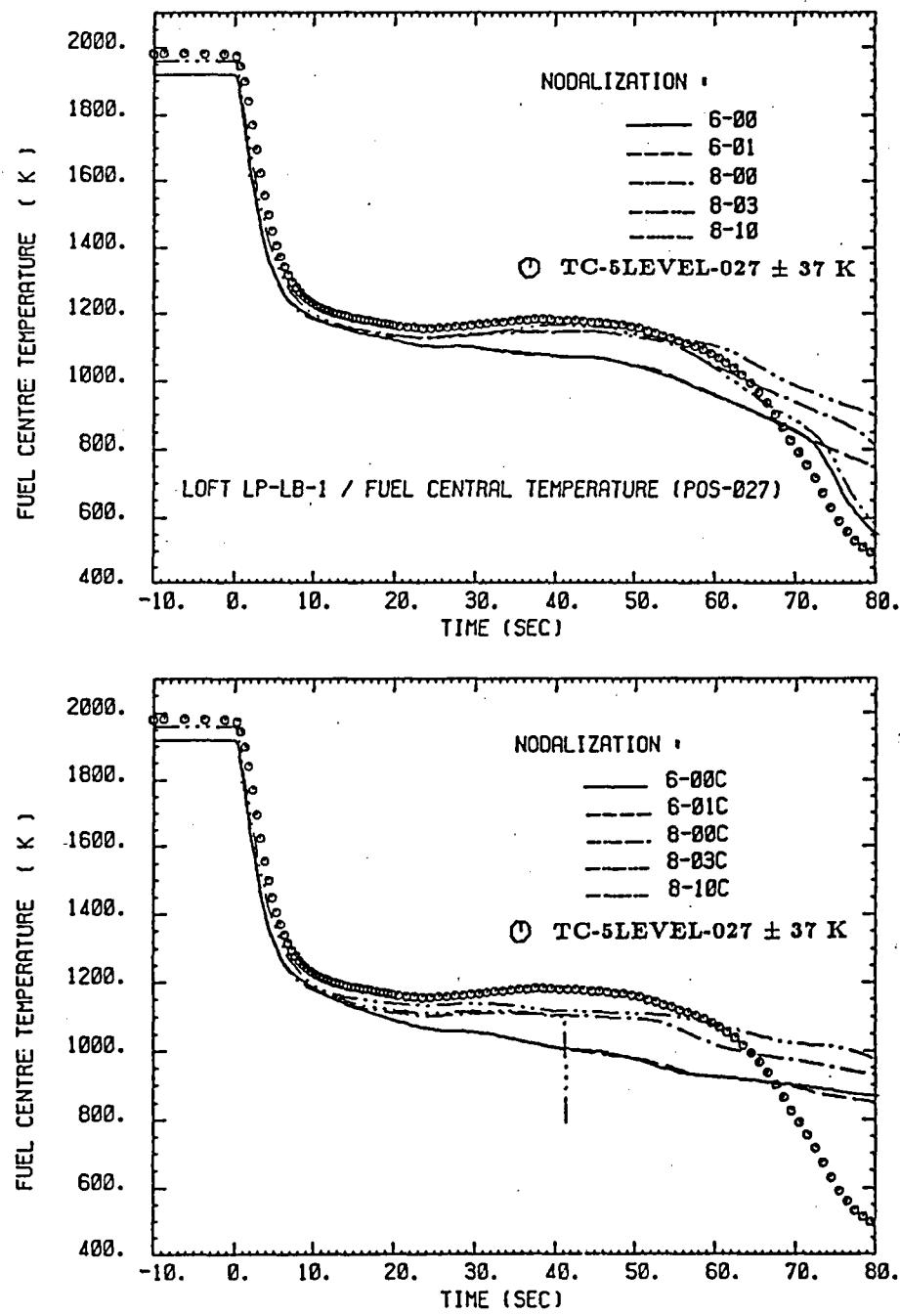


Figure 3.28: Fuel center temperature in the hot channel at level-27 compared with averaged fuel temperatures measured at level-27

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

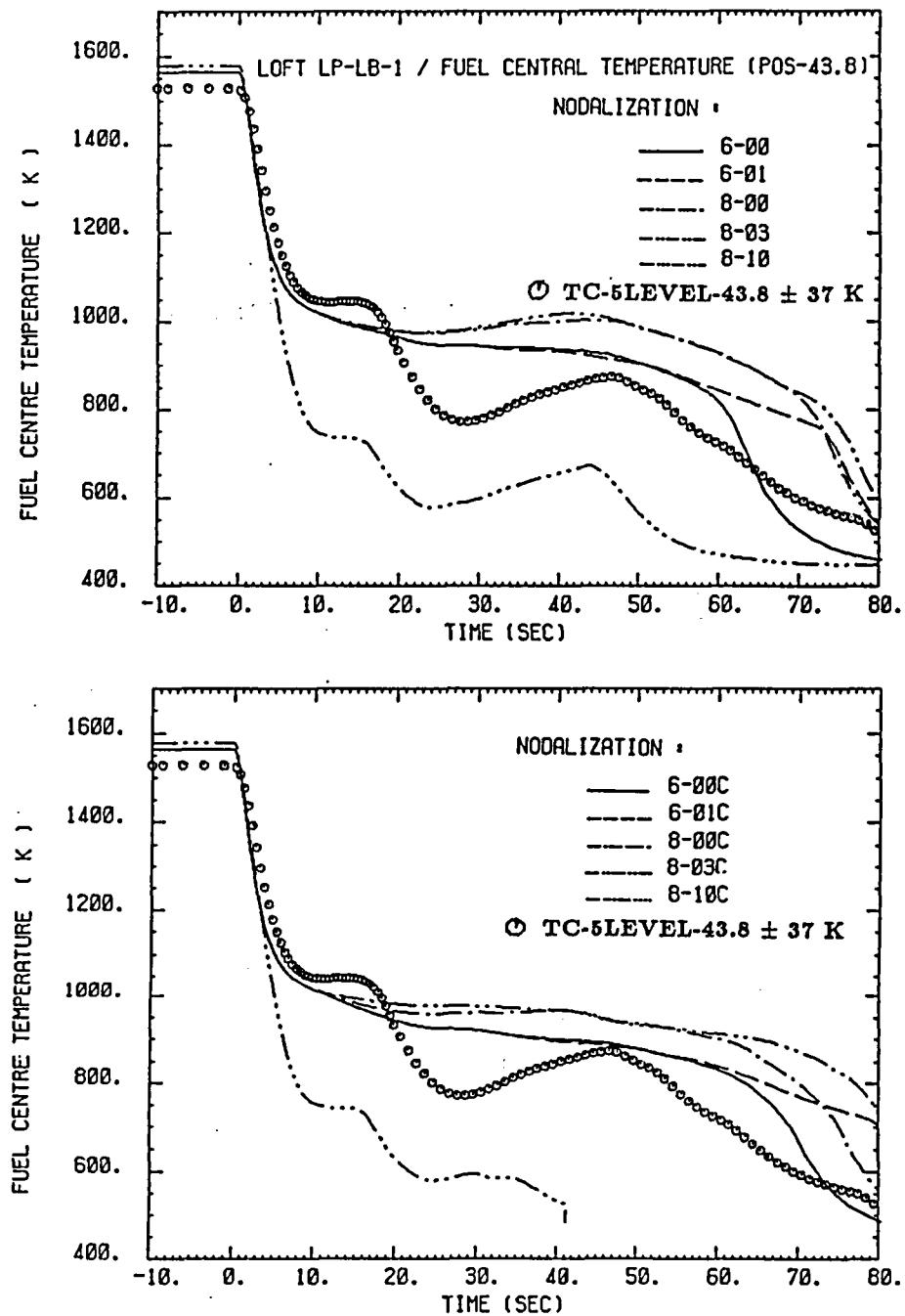


Figure 3.29: Fuel center temperature in the hot channel at level-43.8 compared with averaged fuel temperatures measured at level-43.8
 a) by neglecting wall heat capacity
 b) by taking into account wall heat capacity ("C")

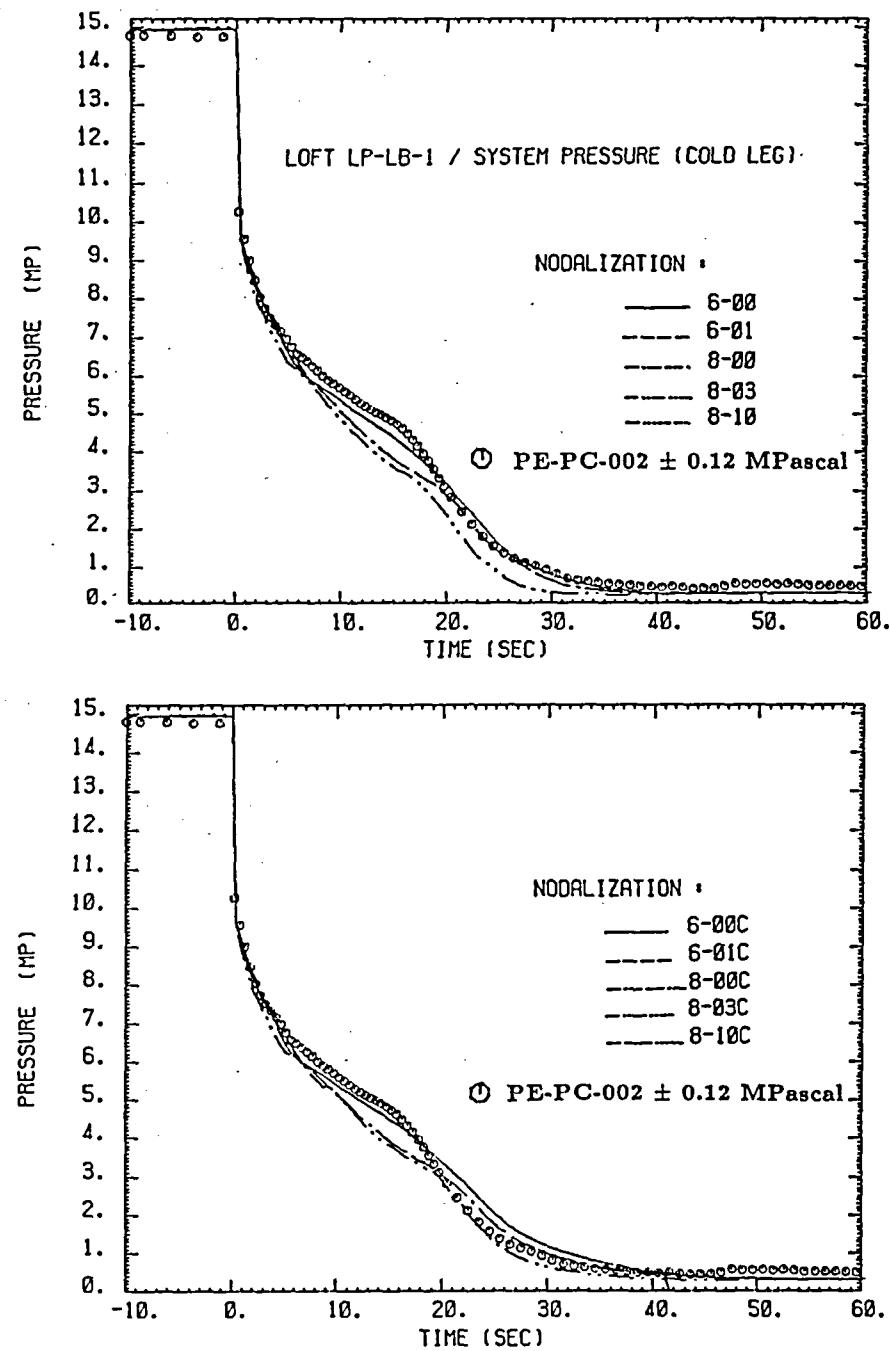


Figure 3.30: System pressures in the cold leg vs. time compared with pressure measured at station PC-002

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

our results into two plots, the upper showing the results of the predictions using the normal nodalizations and the lower showing the ones using the "C" versions. Obviously, for all the different nodalizations, the RELAP5/Mod2 calculations are fairly good even though smaller discrepancies occur between 5 and 30 seconds of the transient. Closest to the experimental findings seem to be the calculations of versions 6-00, 6-01 and equivalent "C"-versions, i.e. the results of calculations using the most detailed type of nodalizations of the LOFT-system.

Compared to those of the system pressure, the predictions of the pressure in the pressurizer have been found less accurate as one may see in figs. 3.31a and 3.31b. Here, the calculations of the runs with 8... type of nodalization, i.e. the cases with a reduced modelling of the pressurizer (instead of 11 volumes used for the pressurizer in the standard version 6-00, in the 8... versions only 5 volumes have been used), are fairly poorer than those of the standard version 6... which sufficiently follow the experimental data. Especially between 3 and 20 seconds, the underprediction of RELAP5/Mod2 runs using 8... nodalizations may exceed 2 MPa. These deviations only occur in the pressurizer and are not to be found at any other location in the system; we therefore believe that these deviations are tolerable for the course of the transient because the predictions of the pressure inside the pressurizer seem to be of secondary importance.

3.4.4 Fluid-Temperature in the Downcomer

Besides the system pressure, the fluid temperatures in the downcomer may be important

with respect to the void formation in the core region because these temperatures are more or less identical to those at the entrance of the core, provided a positive flow out of the downcomer into the core region occurs. Therefore, in figs. 3.32a and 3.32b, we would first like to compare the fluid temperatures as predicted by RELAP5/Mod2 using the different nodalizations with equivalent temperature traces as measured in the downcomer at position 1ST-005.

The initial values of the fluid temperatures have been predicted fairly well (-10 to zero seconds). This is also the case for the following time interval between zero and approximately 20 seconds where the temperatures follow the saturation line. Because of the rapid drop of the system pressure, the fluid temperature becomes saturated at about 8 seconds after initiation of the transient.

For all the versions of nodalizations, the fluid temperatures start to deviate from saturation at approximately 22 seconds and reach the saturation temperature again at about 50 seconds. Beginning at 42 seconds, the system pressure is more or less constant (see figs. 3.30a and 3.30b). The straight line in figs. 3.32a and 3.32b for times higher than 50 seconds can be regarded as the saturation temperature at this pressure, i.e. all temperatures below this line indicate subcooled fluid. Consequently, RELAP5/Mod2 predicted a certain amount of liquid subcooling in the time interval between 20 and 50 seconds which has reached peak values of up to 45 K for all of the "non-C" versions of nodalization and peak subcoolings of 35 degrees for most of the "C" versions. On the other hand, the thermocouple signals have indicated a significant "liquid superheat" of nearly 15 K which probably is due to a dry out of the thermocouple tip, measuring something in between saturated steam tempera-

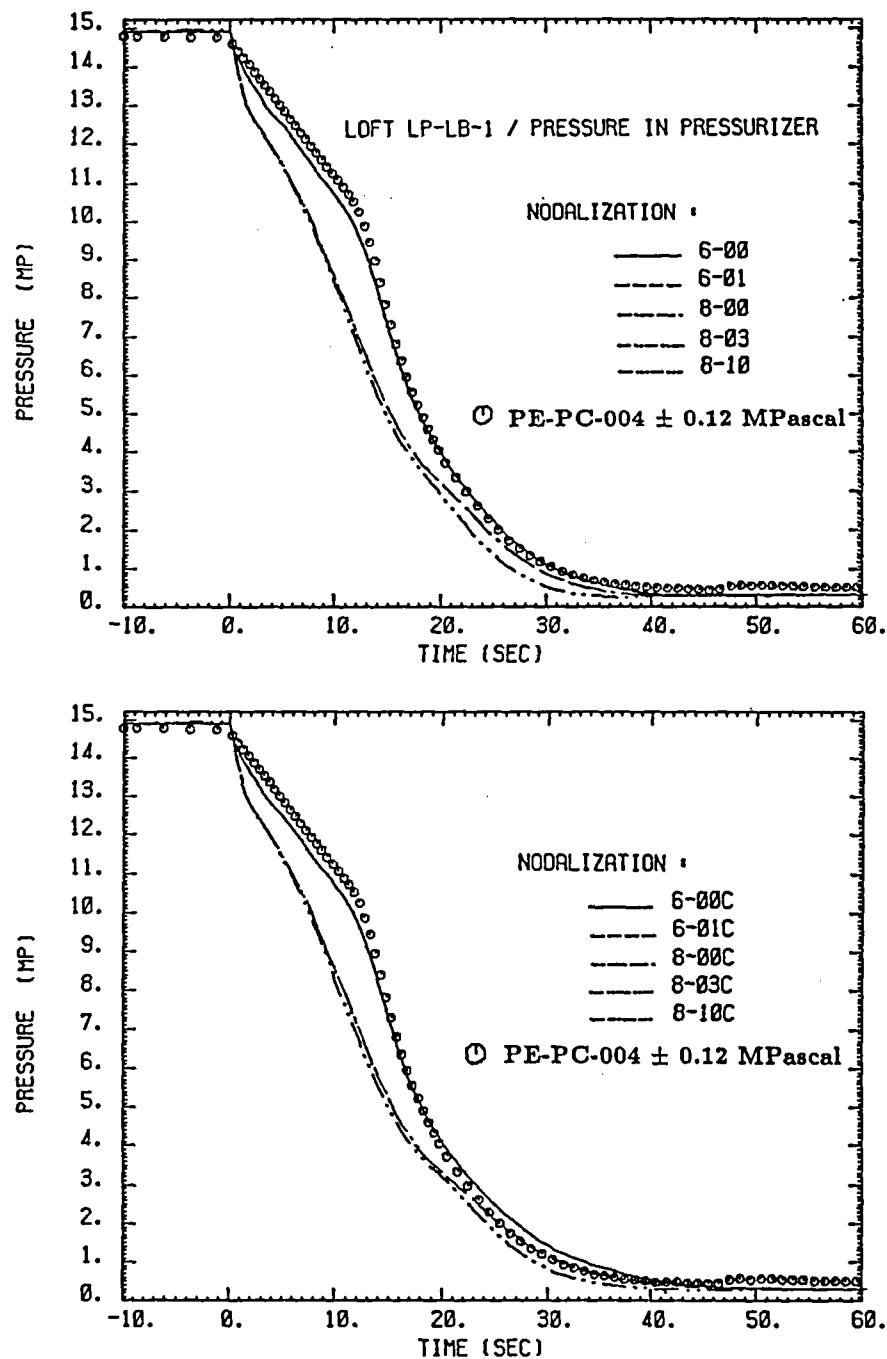


Figure 3.31: Pressures in the pressurizer vs. time compared with pressure measured at station PC-004 of the pressurizer

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

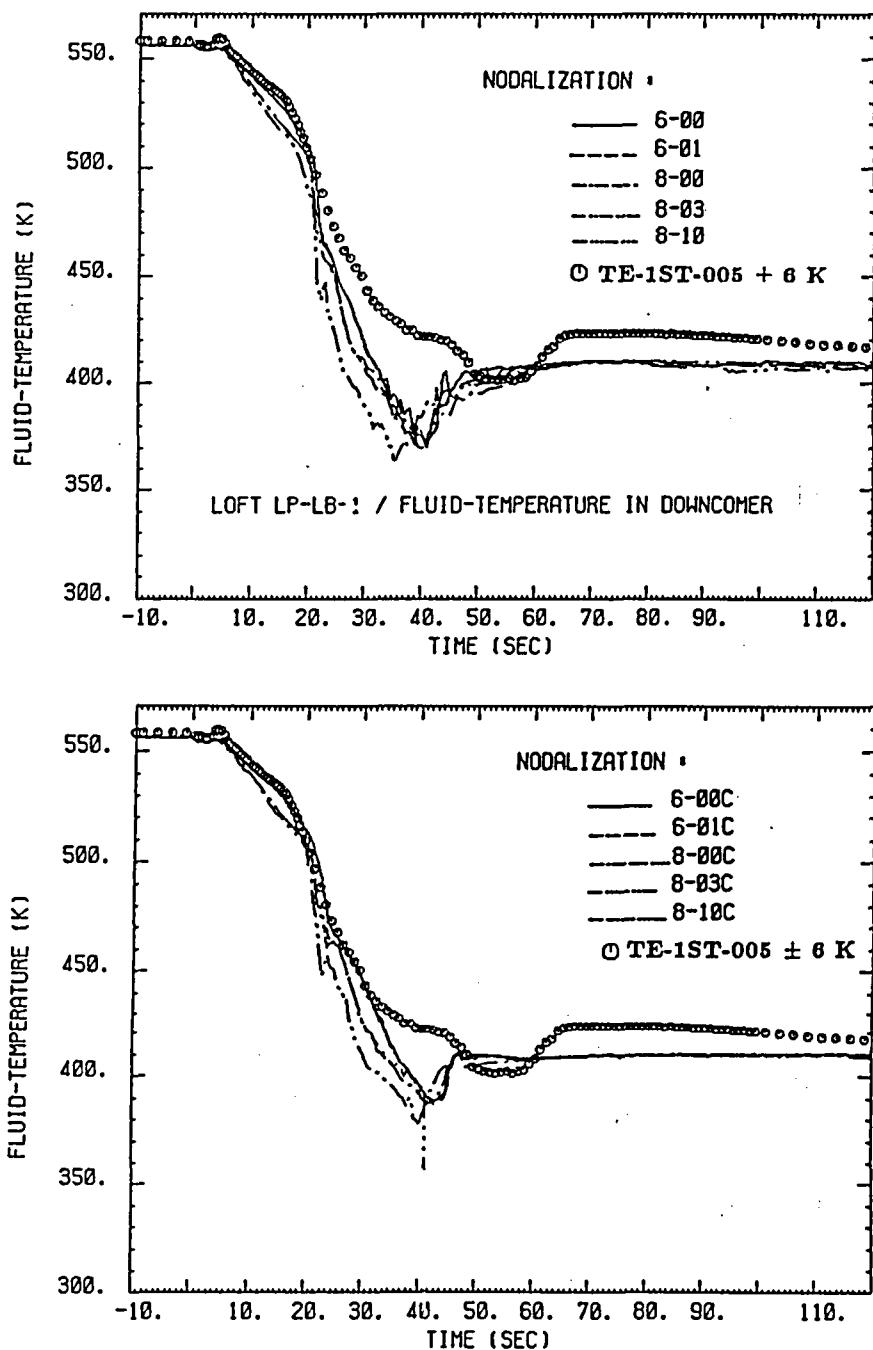


Figure 3.32: Downcomer fluid temperatures vs. time compared with fluid temperatures measured at station 1ST-005

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

ture and thermocouple heat-up due to radiation heat transfer.

3.4.5 Core Mass Flows

Now, we have to look at mass flows into and out of the core as calculated by RELAP5/Mod2. In figs. 3.33a and 3.33b, the mass fluxes into the core and in figs. 3.34a and 3.34b, the mass fluxes out of the hot channel have been plotted. Unfortunately, no corresponding experimental reference data are available.

In figs. 3.33a and 3.33b, the inlet mass fluxes into the hot channel as calculated by RELAP5/Mod2 using different nodalizations have been plotted. Generally, depending on the nodalization, the mass fluxes are slightly positive only for some seconds between 6.5 and 11 seconds time of transient and then remain around the zero line. Consequently, only a very small amount of water has been pumped into the core during the blow-down phase of the experiment.

The mass-fluxes out of the core (figs. 3.34a and 3.34b) behaved similar. For the first 6 seconds, the flux is again strongly negative, i.e. the fluid flows from the upper plenum through the core into the downcomer. Then a short time of positive flux can be observed followed by nearly zero flux conditions.

With respect to top-down rewetting, one of the key phenomena of experiment LP-LB-1, which RELAP5/Mod2 failed to describe properly (figs. 3.12 to 3.14) but which has been observed within the experiment between 15 and 20 seconds after its initialization at the higher levels of the core, figs. 3.34a and 3.34b allow us an insight view into the actual hydraulic conditions inside the core as calculated by the code. From these figures, our conclusion can only be that even if the models within RELAP5/Mod2 theoretically

would be able to predict top-down quenching, in our case the code was bound to fail because there was not enough mass flux to allow top-down rewetting.

Somehow related to the mass fluxes are the momentum fluxes. Therefore, in addition to the mass fluxes, we shall plot the in- and outflow momentum fluxes in figs 3.35a, 3.35b, 3.36a and 3.36b, because for these parameters experimental references are available. Although these references inferred from very local measurements (small drag bodies) and as indicated in the individual plots observed high transducer uncertainties, they may allow us to see a trend of the time behaviour of the mass flows. Indeed, the time traces of the momentum fluxes and mass fluxes as calculated by RELAP5/Mod2 behave quite similar.

Whereas the momentum fluxes at the entrance of the core (figs. 3.35a and b) calculated by RELAP5/Mod2 are comparable to the measured ones both qualitatively and quantitatively, the momentum fluxes at the core outlet differ significantly from the measurements (fig.3.36a and b). If we concentrate on times between 10 and 20 seconds (the time period where top-down rewetting has occurred during the experiment), we are not able to find any negative values of the experimentally inferred momentum fluxes which could enable the top-down rewetting.

Comparing the results of the different RELAP5/Mod2 calculations to each other, we cannot find significant differences.

3.4.6 Core Average Liquid Fractions

Very important for the behaviour of the cladding temperatures are the average liquid fractions in the core region (identical to

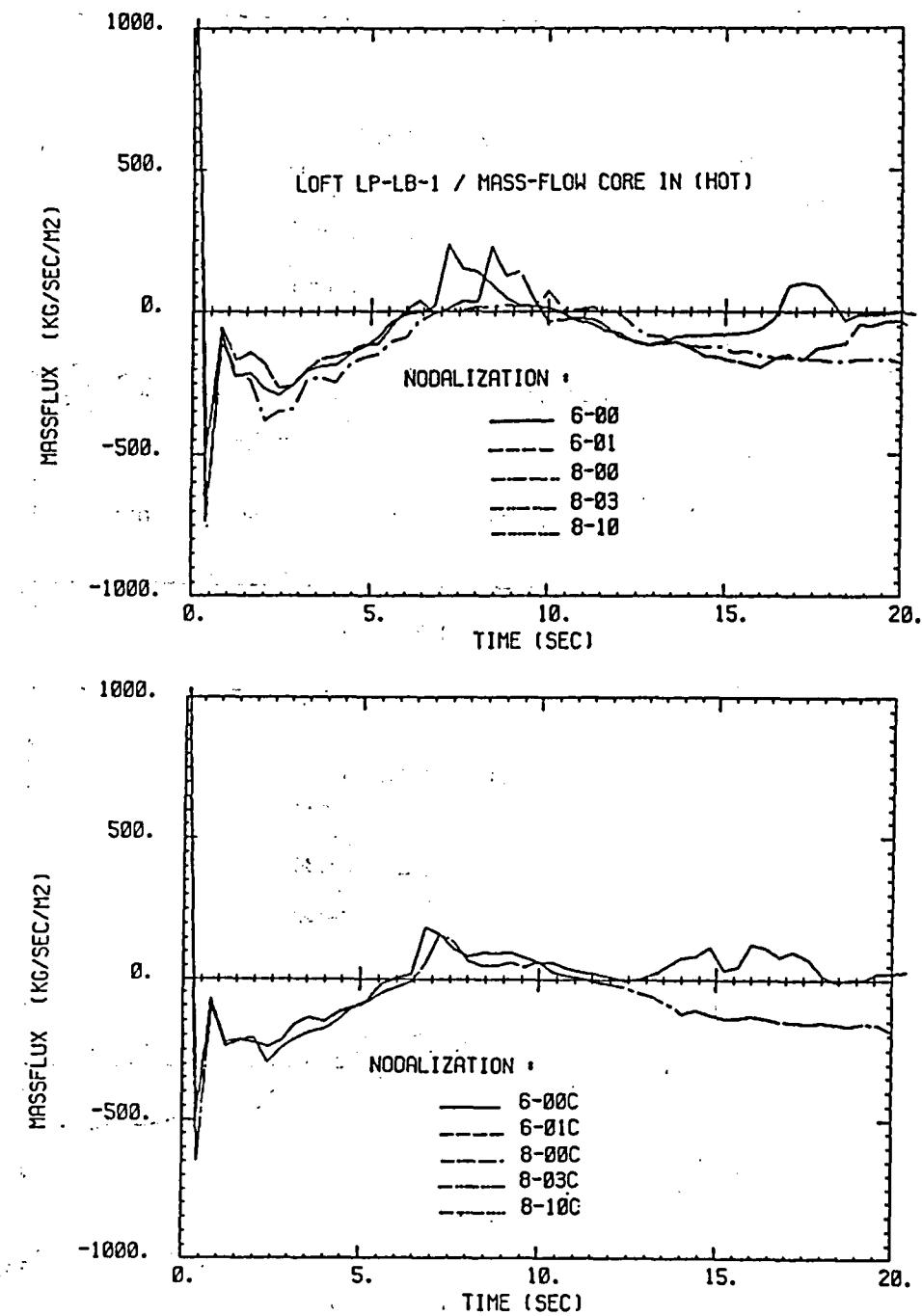


Figure 3.33: Mass fluxes into the hot channel of the core as calculated by RELAP5/Mod2

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

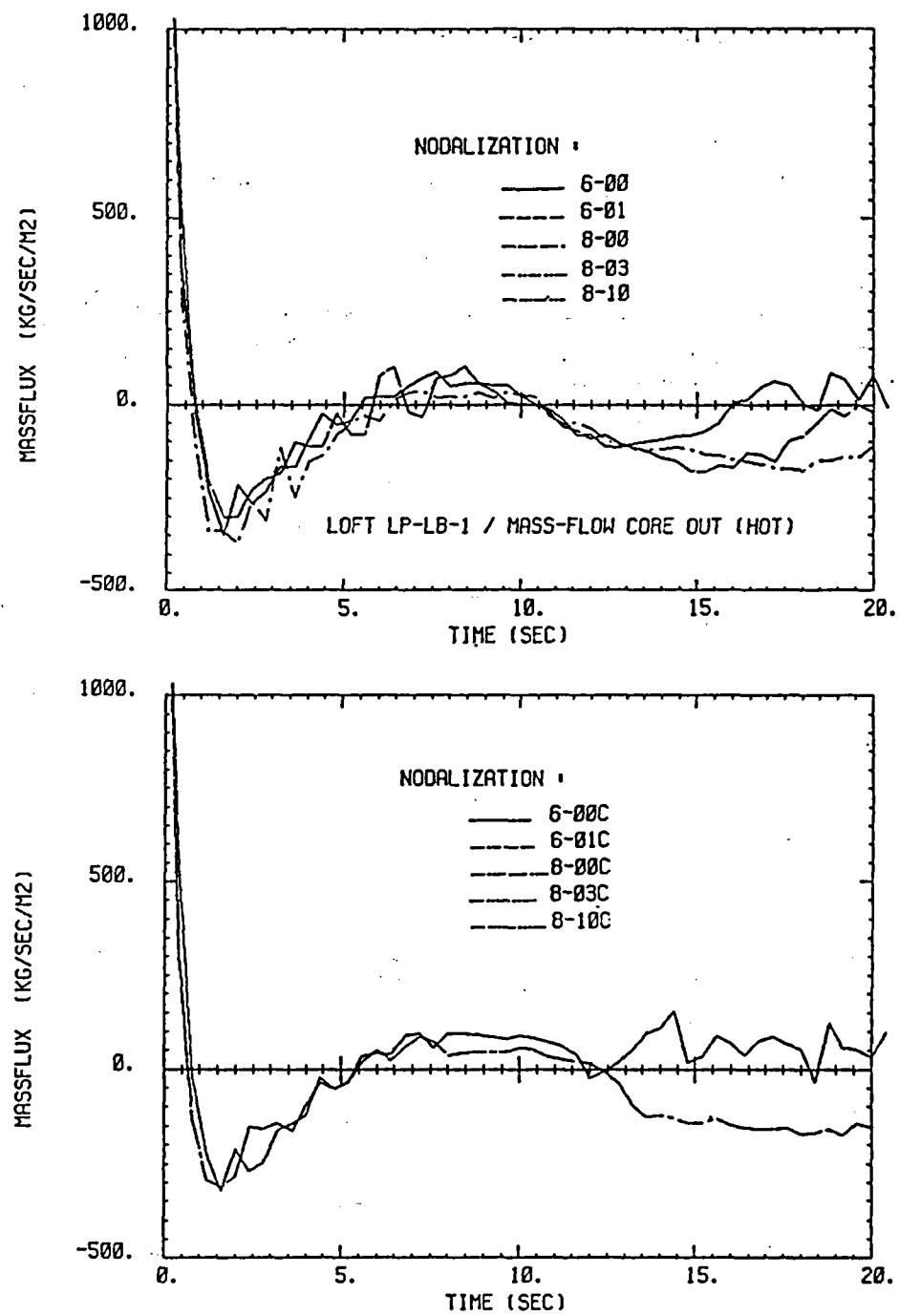


Figure 3.34: Mass fluxes out of the hot channel of the core as calculated by RELAP5/Mod2

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

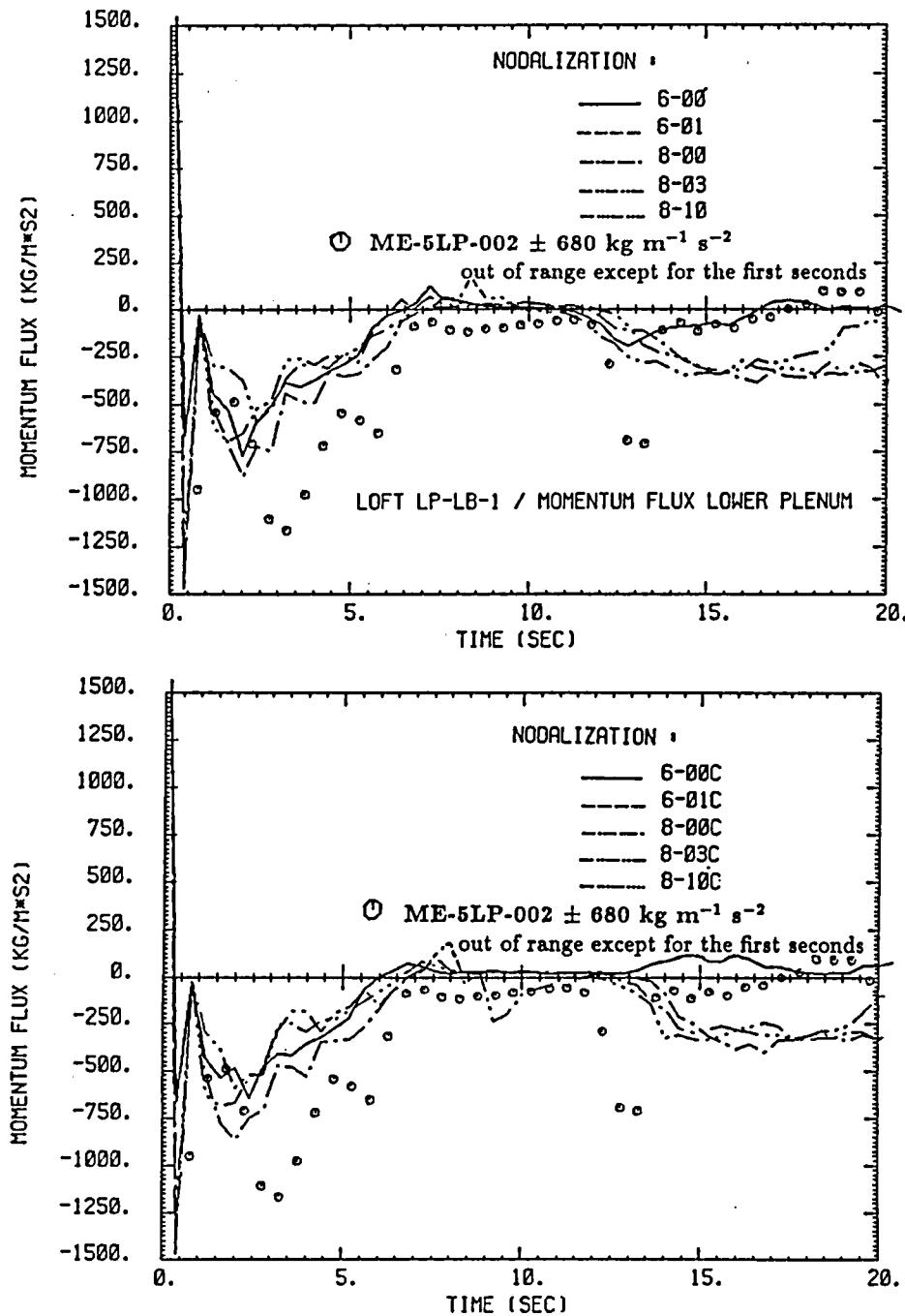


Figure 3.35: Momentum fluxes into the hot channel of the core as calculated by RELAP5/Mod2

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

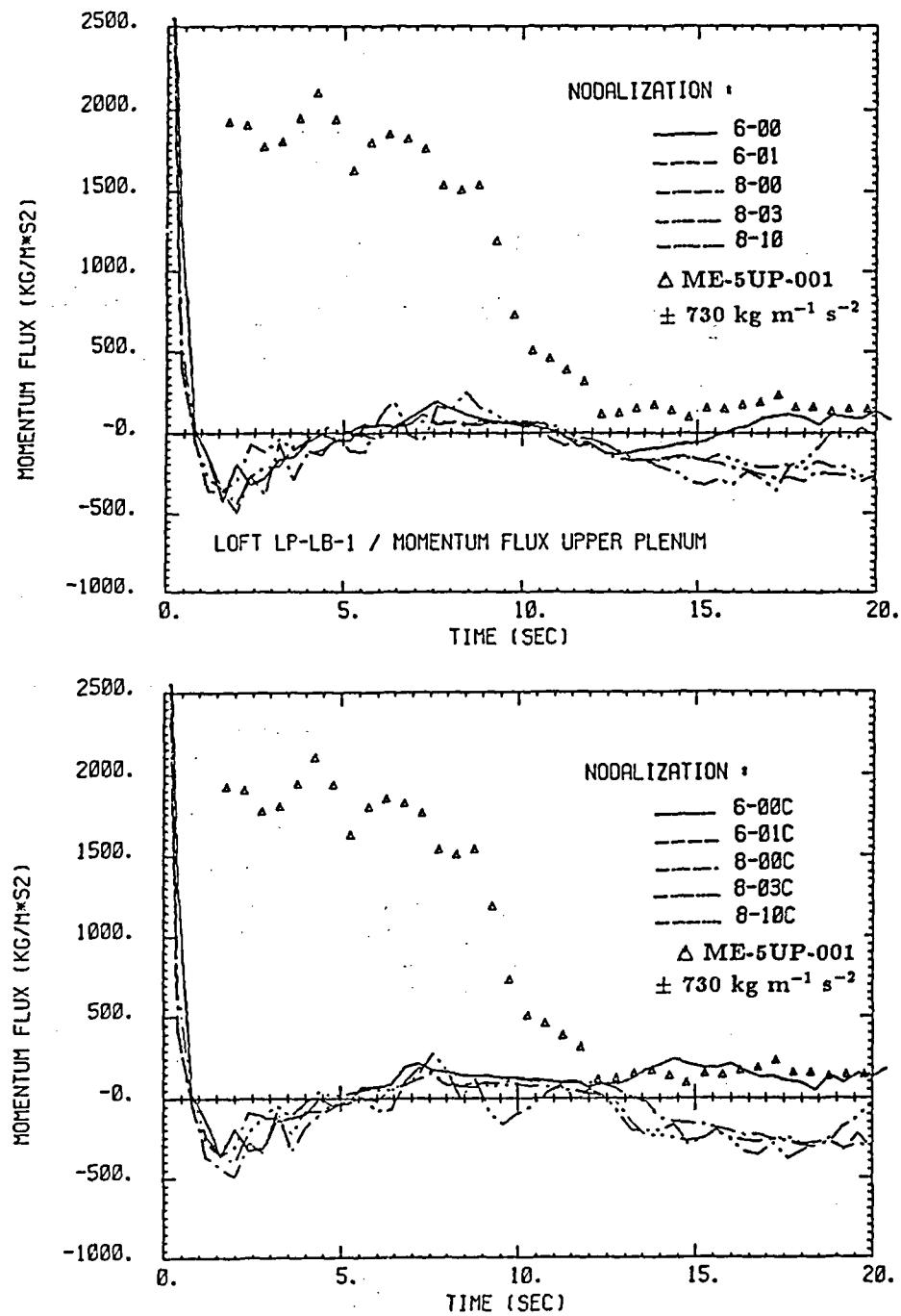


Figure 3.36: Momentum fluxes out of the hot channel of the core as calculated by RELAP5/Mod2

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

the relative collapsed liquid levels) because low liquid fractions are essentially necessary to allow core heat-up whereas increasing liquid fractions are the consequence of a refilling process. Therefore, in figs. 3.37a and 3.37b, the average liquid fractions as calculated by RELAP5/Mod2 for different nodalizations have been plotted. Unfortunately, for this very important quantity again no experimental references have been available.

For all the different nodalizations, RELAP5/Mod2 calculated a minimum liquid level at approximately 30 seconds after initiation of the experiment. Afterwards, liquid fractions increase indicating the refill process. This refill process is clearer seen in the RELAP5/Mod2 -results of the "non-C" nodalization (fig. 3.37a) than in those of the "C" versions. A minor increase of the liquid fraction may be observed between 10 and 20 seconds which might have caused the "cool-down" at very low and very high core levels.

According to fig. 3.37a, the results of runs using the "non C" types of nodalization indicate that refilling has been terminated at approximately 65 seconds where the collapsed liquid level remained quite unstable. The results of the runs using "C"-types of nodalization end up with much lower refill rates (fig. 3.37b) which, on the other hand, seem to be quite stable.

3.4.7 Mass-Flow Out of the Broken Loop

The comparison between predicted and experimental mass flows out of the break of the broken loop allows us to check the capability of RELAP5/Mod2 to describe two-phase flow under critical flow conditions. Therefore, in figs. 3.38 to 3.40, we would like to compare the RELAP5/Mod2 calculations of the mass flows in the cold and in the hot leg of the bro-

ken loop as well as the integral mass loss with the equivalent experimental data; the latter gives a clearer picture how calculations and experimental data deviate. Nevertheless, one has to keep in mind that mass flow measurements in transient two-phase flows are also a rather difficult task, because the data are the result of a multiplication of two independent measurements which are assumed to produce area averaged values.

In figs. 3.38a and 3.38b, let us start with the mass flow in the cold leg of the broken loop. When opening the break valves, for a few hundred milliseconds the fluid is sub-cooled and the mass flow reaches its maximum value of 515 kg/s which value is slightly overpredicted by all the RELAP5/Mod2 calculations. During the following time period, some instabilities have occurred for some RELAP5/Mod2 -runs which probably are due to numerical instabilities. These instabilities more often have occurred in more simplified versions of nodalizations, e.g. the 8... versions of nodalization. No severe discrepancies have been observed between the RELAP5/Mod2 results using the "non C" and the "C" types of nodalization but the results of the latter seem to be slightly more stable.

In figs. 3.39a and 3.39b, the mass flows in the hot leg of the broken loop have been plotted versus time. Except for the most simplified 8-03 and 8-03C versions of nodalization (the break line consists of only 4 volumes instead of 11 for the 6-00/6-01 and 8-00/8-10 versions), the peak values of the mass flow during the few hundred milliseconds of sub-cooled liquid flow conditions (measured value 184 kg/s) seemed to be slightly underpredicted whereas the two RELAP5/Mod2 runs (8-03 and 8-03C) overpredicted this peak value 27% and 32% respectively.

Because of the uncertainties of mass flow measuring techniques in stationary and tran-

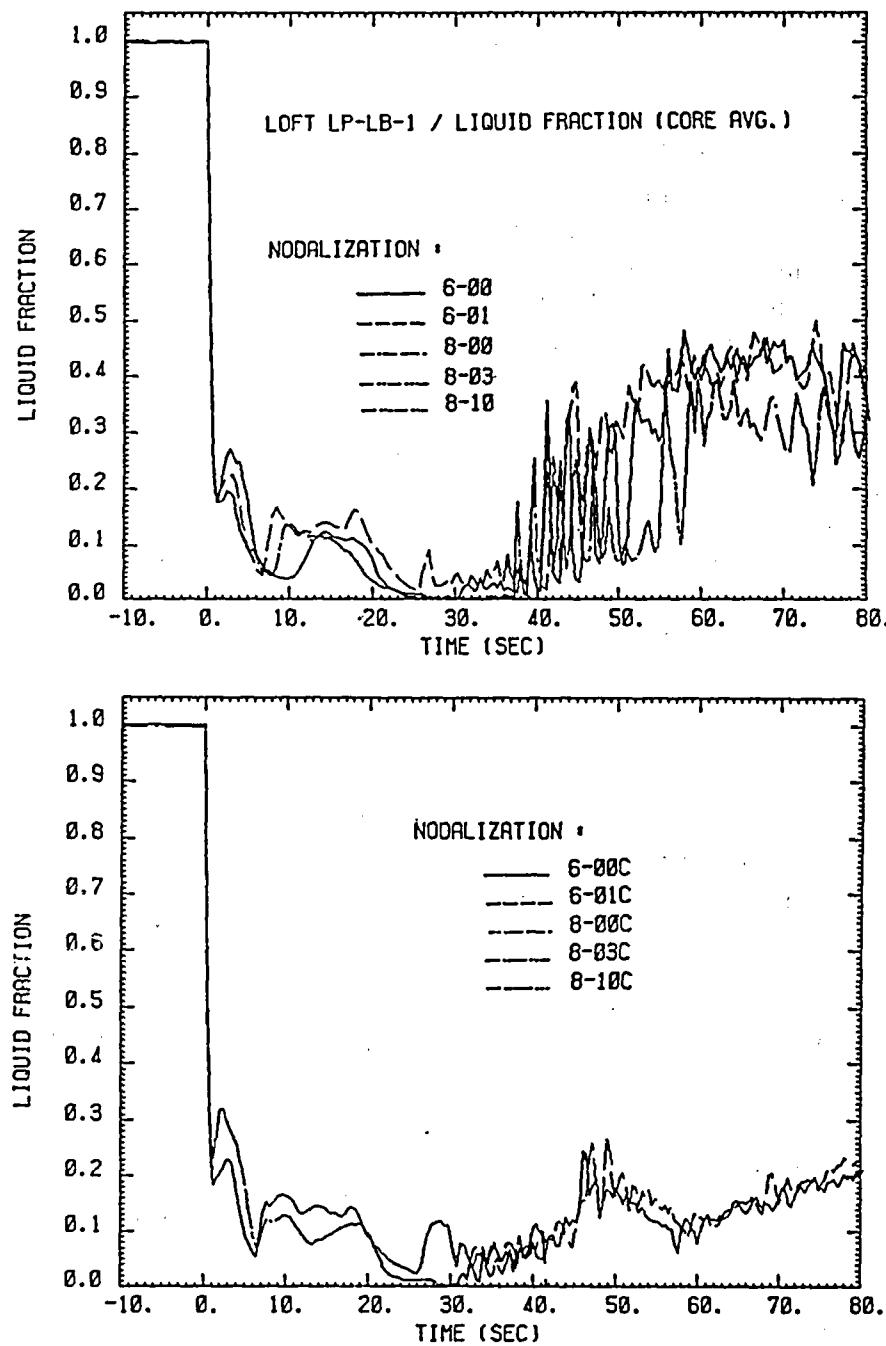


Figure 3.37: Core averaged liquid fractions vs. time as calculated by RELAP5/Mod2

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

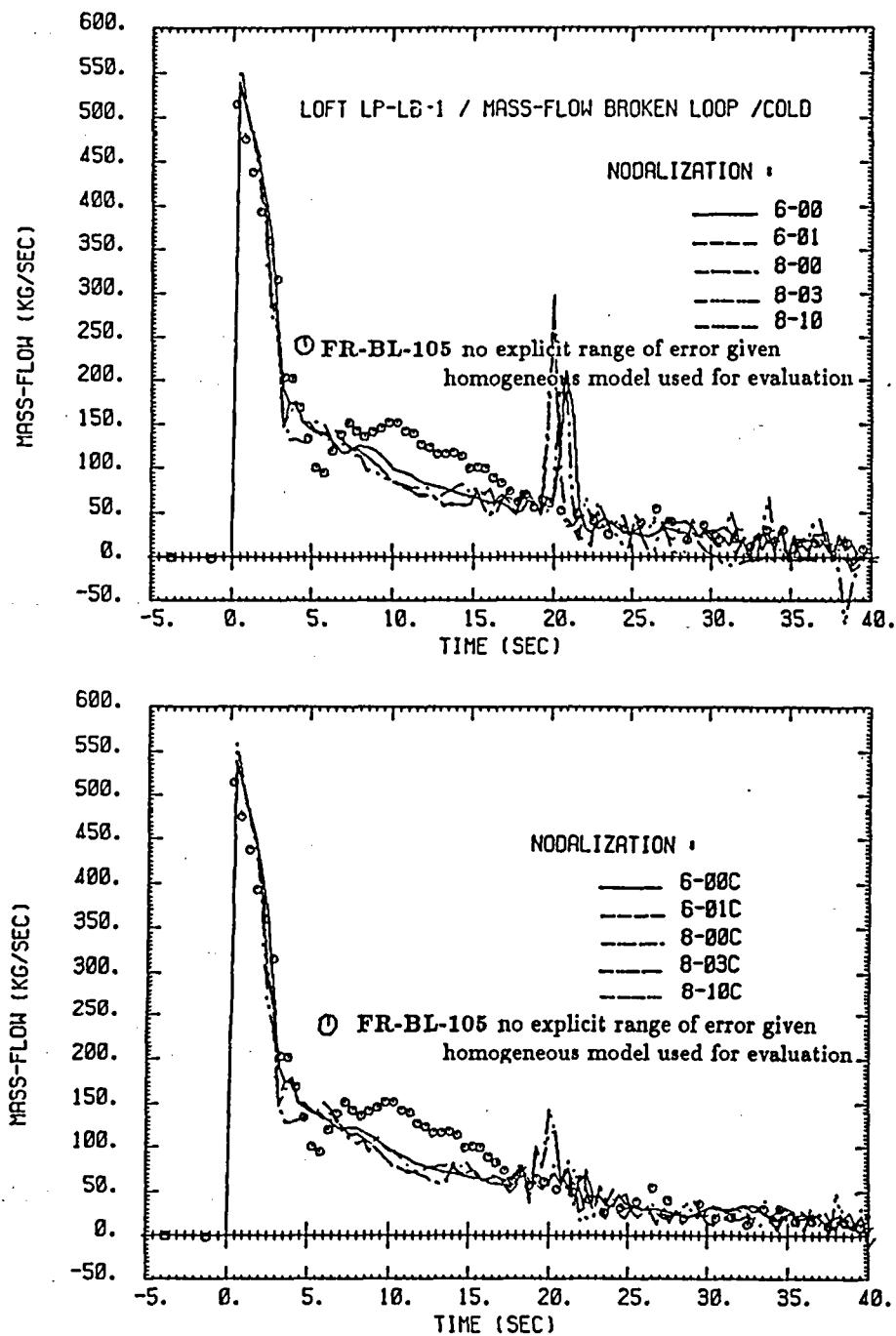


Figure 3.38: Calculated mass flows out of the broken cold leg vs. time compared to the mass flow measured at position BL-105
 a) by neglecting wall heat capacity
 b) by taking into account wall heat capacity ("C")

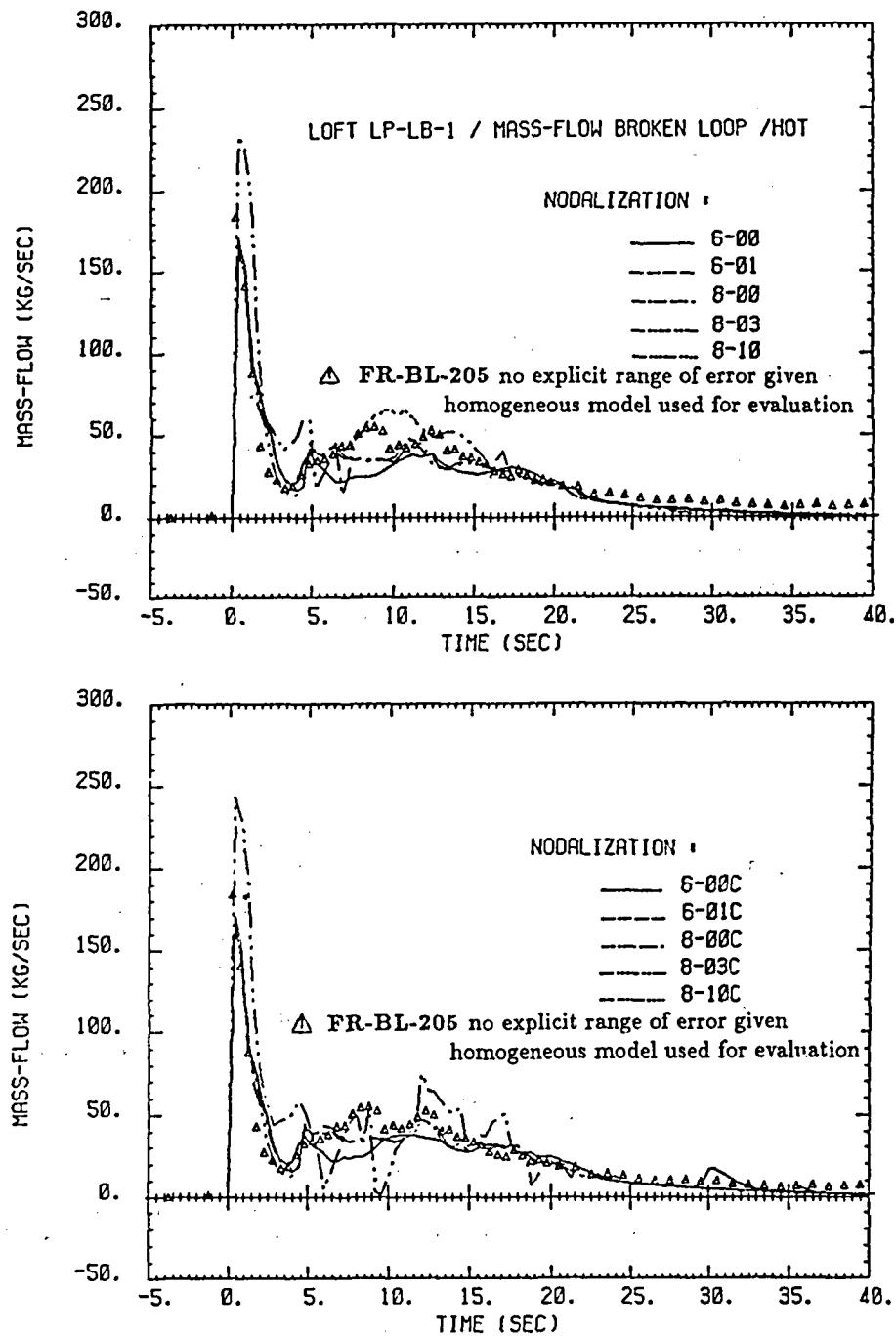


Figure 3.39: Calculated mass flows out of the broken hot leg vs. time compared to the mass flow measured at position BL-205

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

sient two phase flows it cannot be totally excluded that deviations also are due to errors in the experimental reference values.

A plot of the loss of mass focusses more directly on the loss of water inventory rather than the time traces of the individual mass flows through the break. Therefore, we finally shall compare the instantaneous time integrals of the two mass flows in the cold and hot legs of the broken loop (i.e. the mass losses through the break) as predicted by RELAP5/Mod2 with the equivalent values of the measurement. The integration of the mass flows for both the calculations and the experiment has been performed numerically by simply summing up the products of the two instantaneous values of the mass flows (cold and hot leg of the broken loop) times the actual time step.

In figs. 3.40a and 3.40b, these mass losses have been plotted as a function of time. Generally, for all types of nodalizations the mass losses have been overpredicted by RELAP5/Mod2 for the first 45 seconds (6-00/6-01) to 60 (8...) seconds of the transient from which time on the mass-losses more or less stagnated or even slightly decreased. The reason for the latter observation is the fact that the system pressure has decreased to the pressure in the suppression tank (for the code, the suppression tank pressure as a function of time is a boundary condition; the pressure history inferred from experiment LP-LB-1 has been used); RELAP5/Mod2 sometimes calculated system pressures slightly lower than the suppression tank pressures enabling a certain amount of fluid flowing back out of the suppression tank into the primary system; in reality an unphysical process. Because of this backflow (which because of its smallness cannot be seen in the

two plots of the mass flows) and in opposite to the experimental data, RELAP5/Mod2 calculated no significant increase but a slightly decrease of the mass losses. Again, some question marks can be raised with respect to the accuracy of the experimental reference data.

In figs. 3.40a and 3.40b, one may distinguish two different sets of curves, namely, the two 6... type results and the other three results of the 8... nodalizations. For the more detailed 6... nodalizations, the loss of inventory is significantly higher than for the more simplified 8... versions. On the other hand, no severe differences have been observed when looking at the mass losses of the 8-00/8-10 and 8-03 runs even the simplification, especially of the broken loop, has been rather drastic.

3.4.8 Intact Loop Mass Flow and Pump Speed

In figs. 3.41a, 3.41b, 3.42a and 3.42b, the measured mass flows in the hot and cold legs of the intact loop have been compared with the equivalent quantities as calculated by RELAP5/Mod2 using our different nodalizations. In both cases, the stationary values (-10 to zero seconds) which were derived from the values given in table one (305 kg/s) differ slightly from the measured values. Surprisingly, the measured mass flows in this stationary phase (even if all possible leaks are closed) differ from 295 kg/s in the cold leg to 315 kg/s in the hot leg. With respect to the accuracy of the measurements, the uncertainties of mass flow measurements in two-phase flows as mentioned above, again, have to be taken into account.

In fig. 3.41a and 3.41b, the hot leg mass flows inferred from LOFT experiment LP-LB-1 have been compared to the RE-

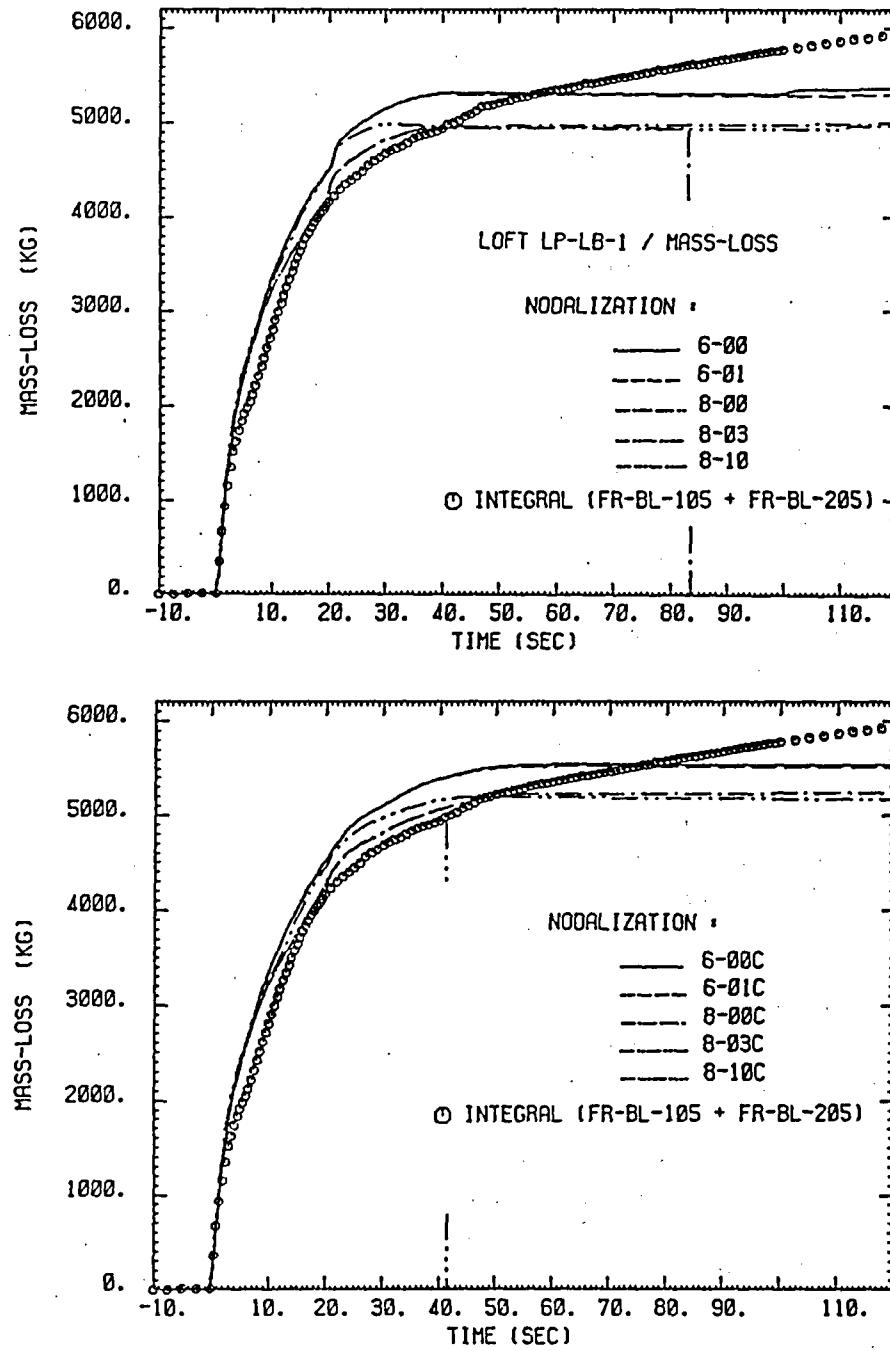


Figure 3.40: Calculated mass losses out of the double ended break vs. time compared to the integrated mass flows measured at position BL-105 and BL-205

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

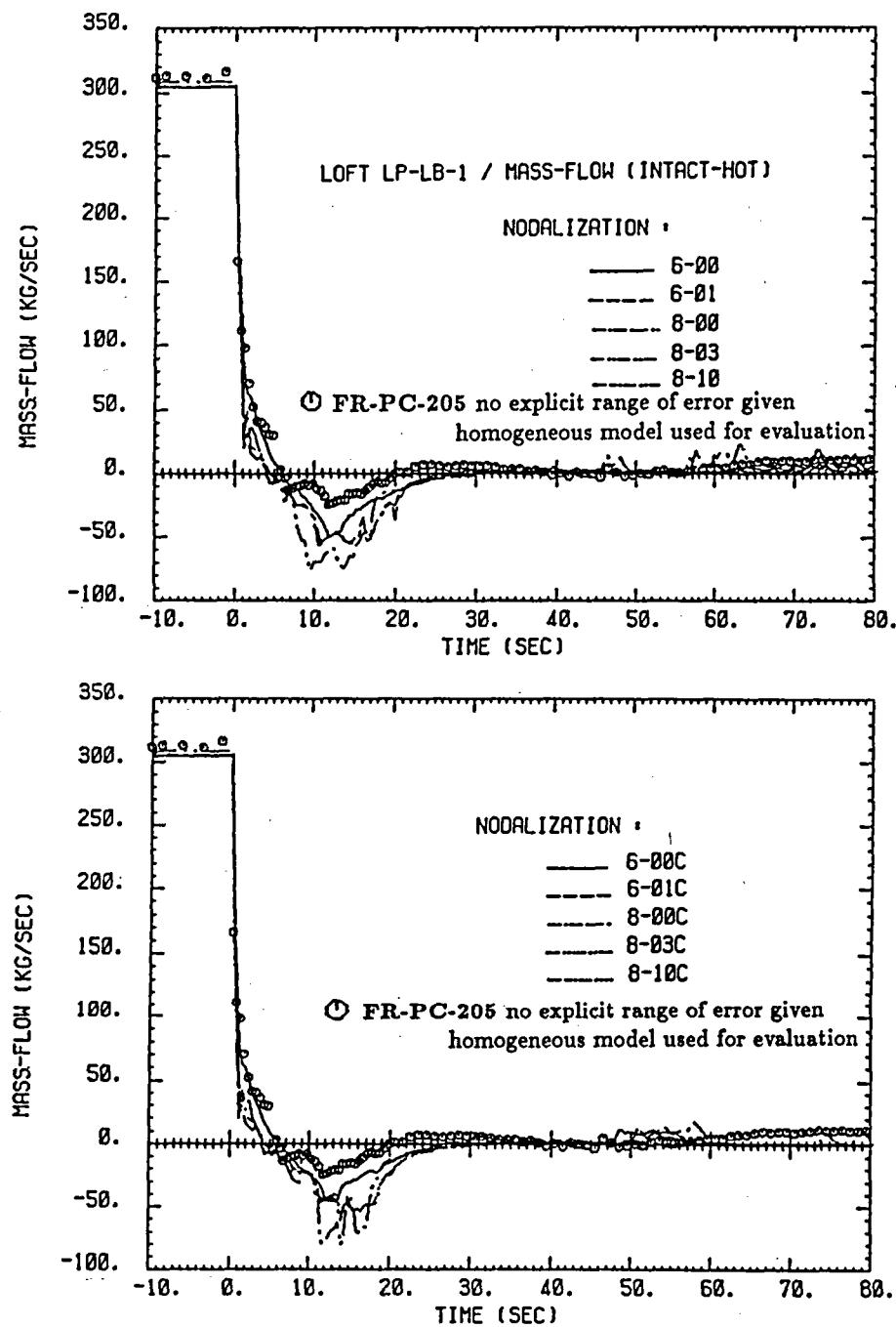


Figure 3.41: Calculated mass flows in the intact hot leg vs. time
compared to the mass flow measured at position PC-205
a) by neglecting wall heat capacity
b) by taking into account wall heat capacity ("C")

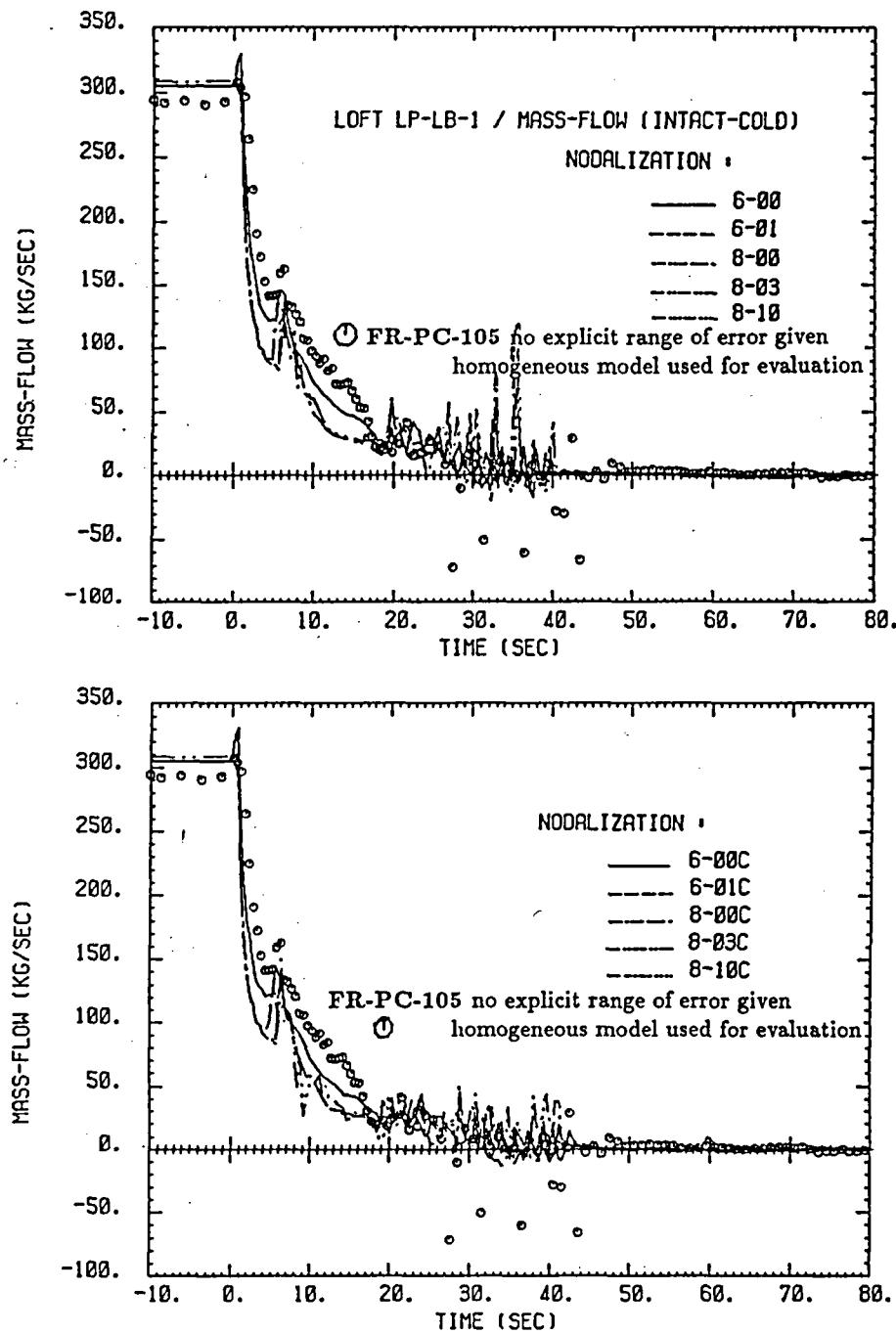


Figure 3.42: Calculated mass flows in the intact cold leg vs. time compared to the mass flow measured at position PC-105

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

LAP5/Mod2 calculations. For the first second (highly transient part of the experiment) and after 30 seconds, the discrepancies between the measurement and all of the calculations with different nodalizations are remarkably small. Between six and 20 seconds, all RELAP5/Mod2 cases have calculated a significant reversal of the mass flow which also is observable to a lesser degree in the measured data. For the time period after 30 seconds, the calculated mass flows are nearly zero, whereas the measurement still indicated some positive amount of flow. But because the measured flowrate is relatively low, it may be due to uncertainties of the measuring technique.

In figs. 3.42a and 3.42b, the mass flow in the cold leg of the intact loop has been compared to the equivalent RELAP5/Mod2 calculations. Generally, the predictions seem to be more unstable than both the experimental data and the hot leg results. Only the curves of very low mass flow at times greater than 45 seconds seem to be somehow smoother. The stepwise increase of the experimentally inferred mass flow immediately after opening of the break valves (295 kg/s to 310 kg/s) has been slightly overpredicted by all the RELAP5/Mod2 runs. A second increase of the mass flow at approximately 7.5 seconds again has been overpredicted by all the RELAP5/Mod2 runs.

Relatively high instabilities of the mass flow occur both in the results of all of the calculations as well as in the experimental data between 20 and 40 seconds of the transient, probably due to high thermodynamic unequilibrium during the injection of approximately 35 kg/s of cold water out of the accumulator into the cold leg; this injection has stopped after 40 seconds. With respect to the cal-

culation results, the instabilities are more pronounced in the "non-C" versions of nodalization.

Finally, in figs. 3.43a and b, the relative pump speed, defined as the actual value divided by the initial speed under stationary conditions (because the absolute value of the pump speeds has been used to adjust the intact loop mass flow to the experimental one given on table 1.1, only relative values can be compared) as predicted by RELAP5/Mod2 has been compared to the equivalent average experimental value of the pump speeds of the two individual pumps. For all of the nodalizations, the run-out behaviour of the pumps seems to be in satisfactorily good agreement with the measured data, even the reproduction of the "peak" at 43 seconds is poor for most of the runs. The accuracy of the results of the RELAP5/Mod2 calculations using "non C" nodalizations is slightly higher than using the "C" versions. The best jobs have been done by the more simplified 8... versions of nodalization.

3.4.9 ECC System

In figs. 3.44 to 3.47, experimentally inferred accumulator liquid level, accumulator pressure, accumulator flowrate as well as the flowrates of the low pressure injection systems (LPIS) have been compared to the equivalent RELAP5/Mod2 calculations.

The time point of starting the accumulator injection has been defined by a time-trip (boundary condition) instead of a code calculated pressure trip which would model the LOFT system in a more realistic way, but on the other hand would multiply deviations in the RELAP5/Mod2 calculation of the system pressure to other parameters of interest of the whole LOFT system (e.g. a later start of the ECCS would probably influence signif-

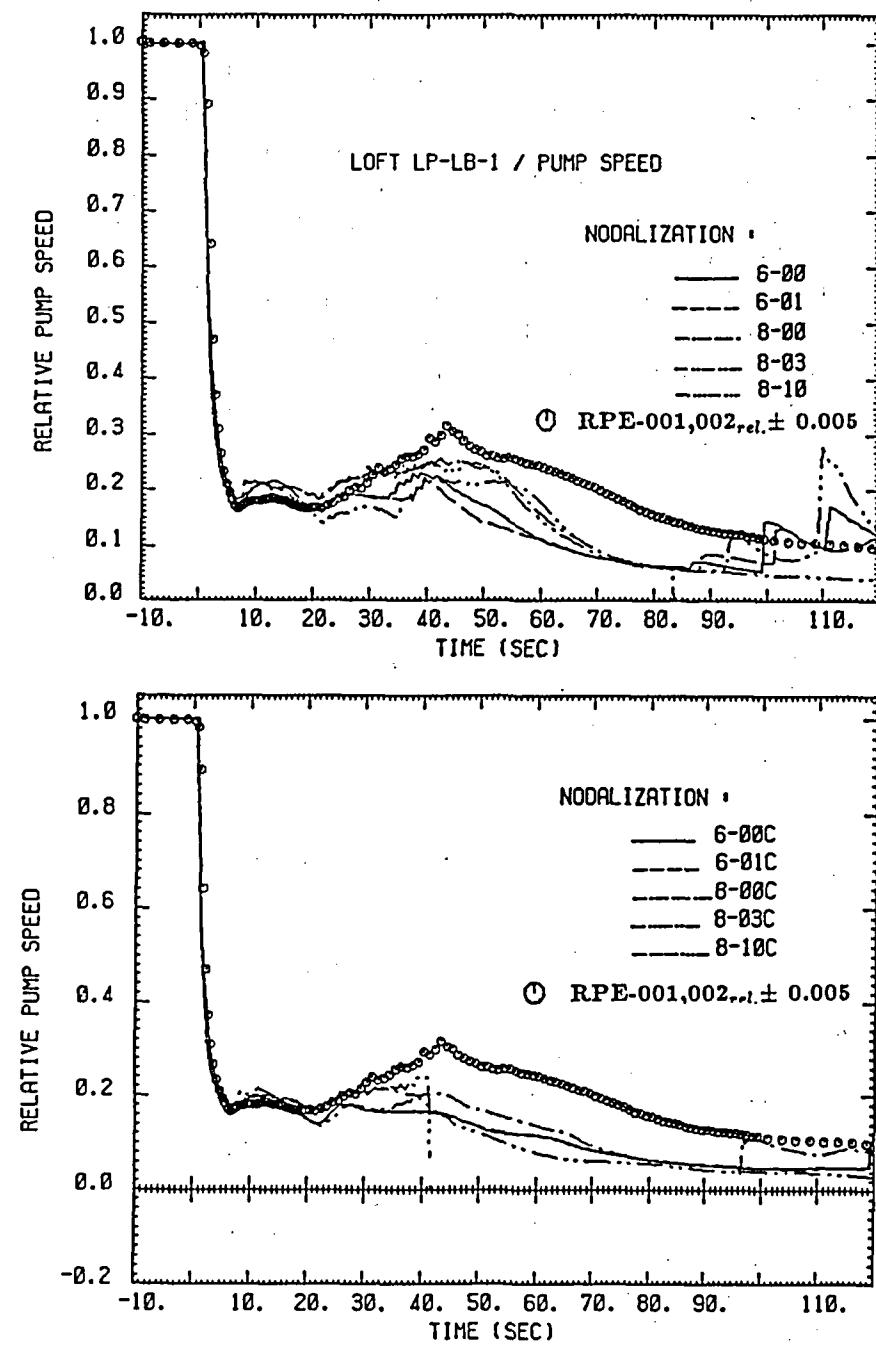


Figure 3.43: Calculated relative pump speed vs. time compared with the measured ones (averaged value of two pumps)

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

icantly the shapes of the cladding temperature traces). Furthermore, the empty-point of the accumulator, i.e. the time when the accumulator level approaches zero, has been adjusted once for all for the 6-00 nodalization by multiplying the forward and backward energy loss coefficients of the accumulator volume by nearly 3; for all the other types of nodalizations, the same coefficients have been used. In addition, it was necessary to close the valve 610 (see figs. 2.1, 2.3 and 2.4) after the accumulator was emptied to avoid an execution error of RELAP5/Mod2 (message: arithmetic overflow). This error is probably due to an improper modelling of incondensibles (nitrogen) by RELAP5/Mod2 ; nitrogen is released by the accumulator into the system after emptying.

First, in figs. 3.44a and 3.44b, the liquid levels in the accumulator as calculated by RELAP5/Mod2 have been plotted in the time interval the accumulator is activated and compared to the experimental data. The curves are satisfactory close to the experimental points. The longest accumulator times have been achieved by using the most detailed 6... types of nodalizations (nodalization of adjustment) which are exactly on time, whereas the results of the other three types of nodalization underpredicted the emptying time of the accumulator not more than 4 seconds.

In figs. 3.45a and 3.45b, the pressure in the accumulator vessel inferred from the measurement has been compared to the equivalent pressures as calculated by RELAP5/Mod2 . Generally, the code tended to slightly overpredict the real pressures but the difference is less than 0.3 MPa. Because in contrary to the experiment, as already mentioned above, for the RELAP5/Mod2 predictions for numerical reasons a valve has to be closed when the accumulator has emptied,

the predicted pressure remained constant after this valve has been closed.

Closest to the measurements we have found the results of the 8-03 nodalizations, i.e. of the most simplified versions of the LOFT system. The poorest results on the other hand have been found to be the results of the 6-00 and 6-01 calculations.

In figs. 3.46a and 3.46b, the flowrates out of the accumulator as calculated by RELAP5/Mod2 using our different nodalizations have been plotted and have been compared to the experimental data. Generally, the results of the calculations are quite satisfactory and more or less have reproduced the mass flow out of the accumulator both qualitatively and quantitatively. Closest to the experimental data we have found the results of the RELAP5/Mod2 calculations using the most simplified 8-03 and 8-03C types of nodalization, whereas the poorest results have been achieved with the most detailed 6-00/6-01 nodalizations.

Finally, in figs. 3.47a and 3.47b, the flowrates of the Low Pressure Injection System (LPIS) have been compared to the equivalent RELAP5/Mod2 results. For all the different nodalizations, the calculated results have been found to be rather poor although with respect to the quantitative aspect of the total mass injected, the predictions are acceptable.

At the beginning of the LPIS action, a sudden decrease from 6 to 4 kg/s followed by an increase from 4 to 8 kg/s can be observed in the experimental data which has not at all been calculated by RELAP5/Mod2 . This strange behaviour of the LPIS mass flow is believed to be due to a short high pressure nitrogen release out of the accumulator into the system at the moment when it has been emptied completely. This nitrogen release for some seconds caused a small increase of

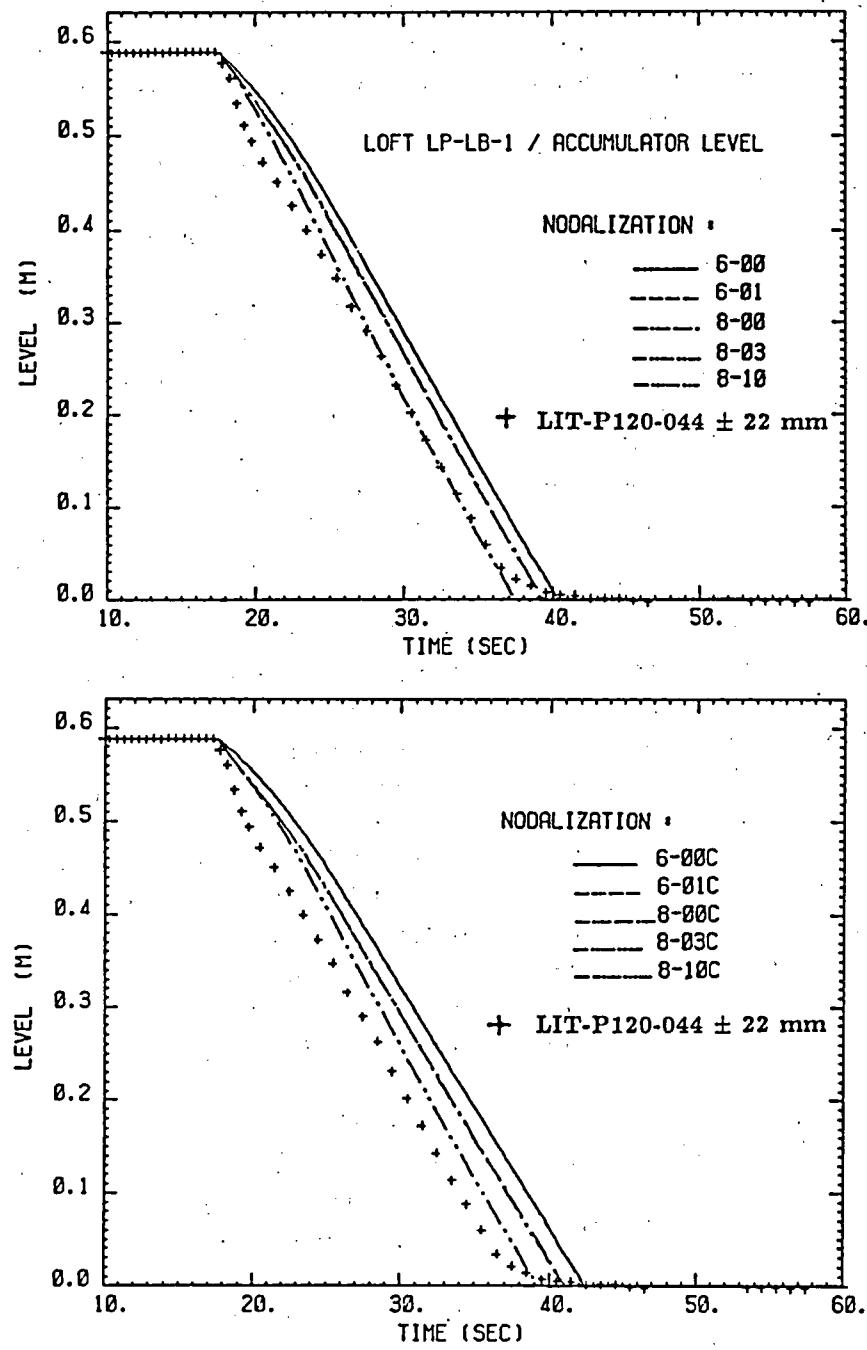


Figure 3.44: Calculated accumulator fluid levels vs. time compared with the measured level

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

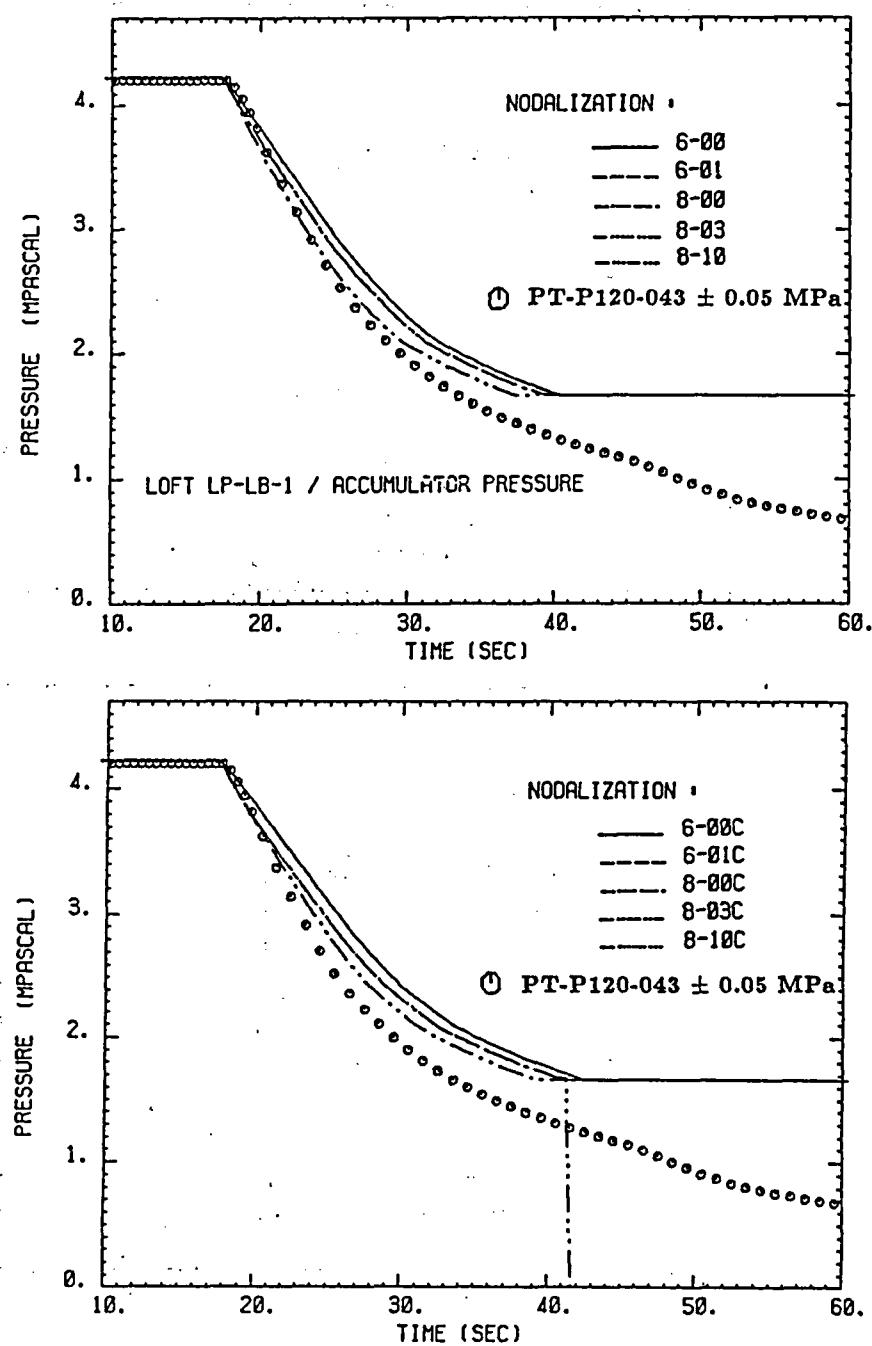


Figure 3.45: Calculated accumulator pressure vs. time compared with the measured pressure

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

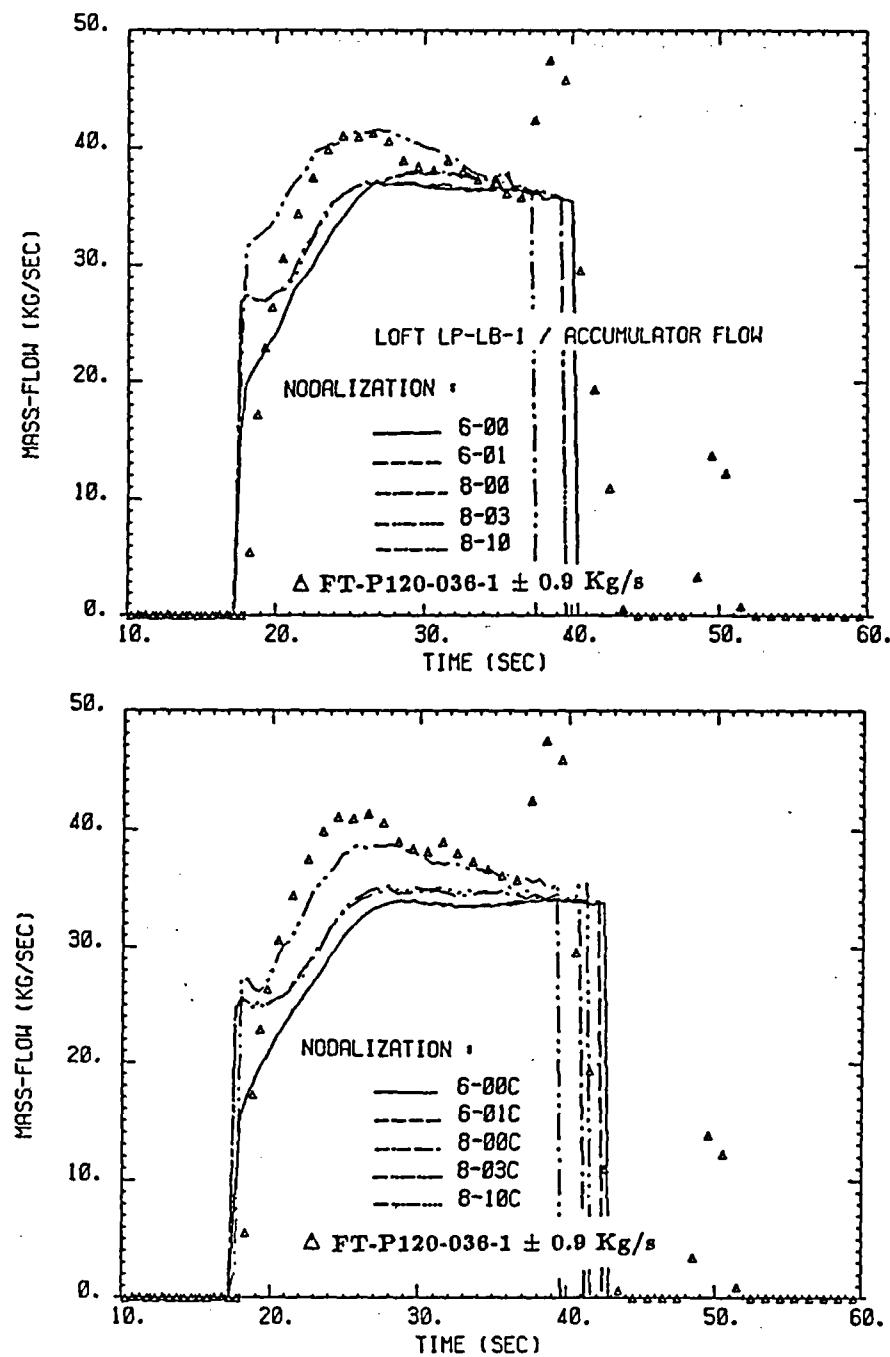


Figure 3.46: Calculated accumulator mass flows vs. time compared with the measured flow rate
 a) by neglecting wall heat capacity
 b) by taking into account wall heat capacity ("C")

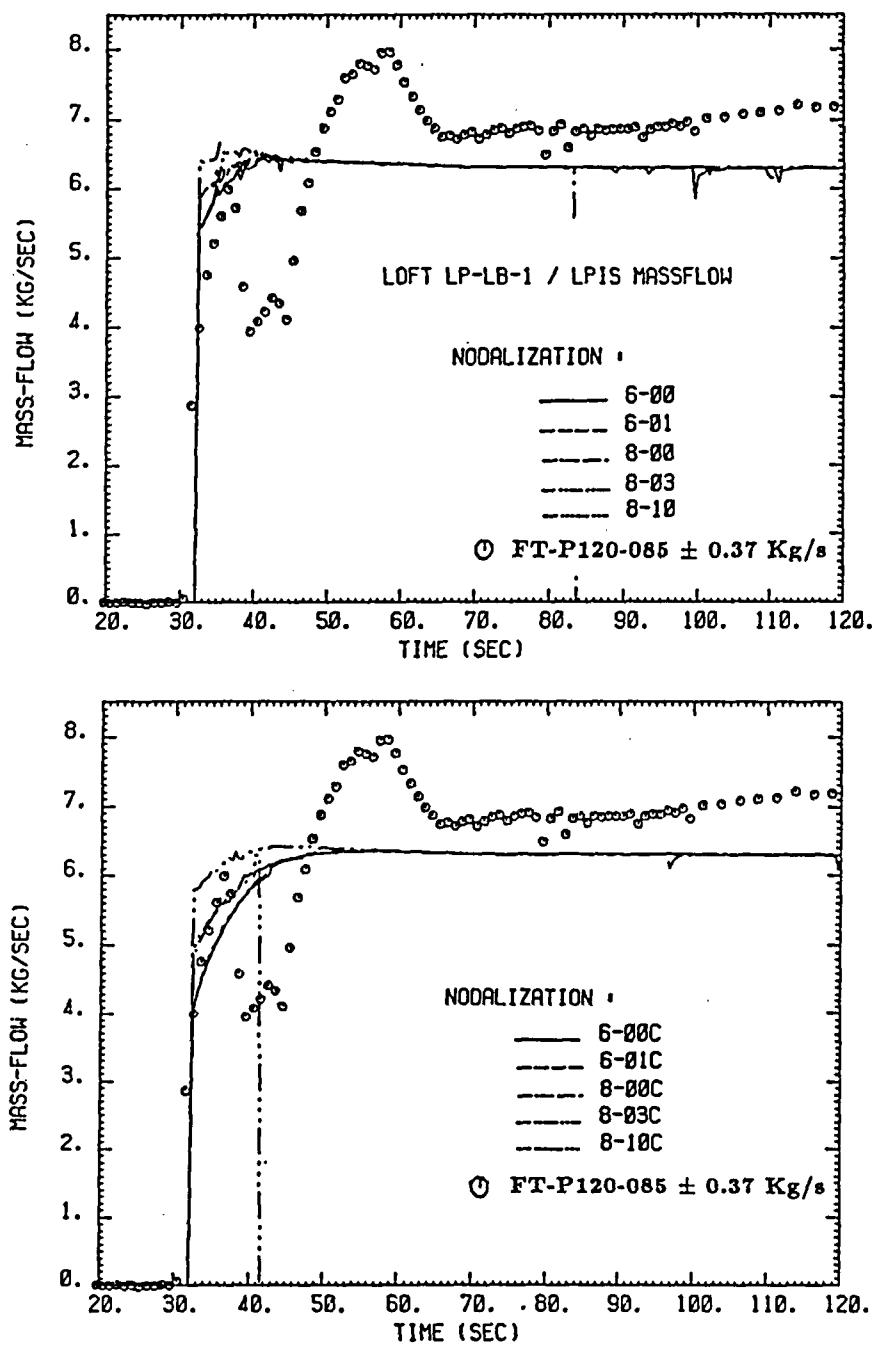


Figure 3.47: Calculated LPIS discharges vs. time compared with the measurement

- by neglecting wall heat capacity
- by taking into account wall heat capacity ("C")

the system pressure (which can be observed in the system pressure data of figs. 3.30a and 3.30b at around 50 seconds) and even a larger increase directly in the ECCS-piping thus reducing the LPIS flow-rate which is governed by the pressure difference between ECCS-piping pressure and the constant LPIS pressure. After some seconds, this increase in the ECCS-piping pressure diminishes and the LPIS flowrate recovered. Because the "nitrogen injection" has not been taken into account by the RELAP5/Mod2 calculations, the code has calculated a more or less smooth curve which is close to the experimental data after the experimentally observed flow instability has been damped and which more or less represents the time-average of the experimentally inferred LPIS mass flow between 35 and 65 seconds.

3.5 Investigation on the Prediction of Top-Down Rewetting

The occurrence of a top-down rewetting front has been regarded as one of the "key-events" of LOFT experiment LP-LB-1 .. This top-down rewetting front quenched the upper 30% of the core between 15 and 20 seconds after initiation of the experiment during the blow-down phase thus reducing the core heat-up in this core region significantly. As we have already seen before, RELAP5/Mod2 was unable to calculate this phenomenon.

One of the features of RELAP5/Mod2 code is the fact that it uses different sets of heat-transfer correlations under non-reflood and reflood conditions (e.g. correlations for nucleate boiling, transition boiling and film boiling). On top of this, the calculation

of the temperature distribution of the fuel rod is enhanced by subdividing the axial length (corresponding to the length of the connected hydrodynamic volume) into several "fine meshes" to better model the occurrence of steep temperature gradients inside the cladding during reflooding. The "switching" from normal operation to reflooding can be achieved by three different methods :

1. external trip (to be set by user defined options)
2. internally set by the code when the connected hydrodynamic volumes are nearly empty
3. internally set by the code when dryout begins in the connected hydrodynamic volumes

In addition, the last two cases are limited to system pressures less than 10 bars. Once the reflood calculation has been initiated, it remains activated until the end of the calculation.

The choice of a slightly different heat transfer correlations combined with a better tracing of the axial cladding temperature distribution by "fine meshing" may have an important influence on the prediction of cladding temperatures. Consequently, the time of the reflood initiation, i.e. the "switch" between both the different sets of correlations and the numerical solution schemes may have an impact on the result. Therefore, one may argue that the calculation of the top-down rewetting by RELAP5/Mod2 in experiment LP-LB-1 only failed because the reflood option has not been initiated between 15 and 20 seconds after the initiation of the transient.

For investigation of this problem, we have performed

three different RELAP5/Mod2 calculations, using nodalization 8-00 with the three reflood initiation options, namely one (8-00T), two (8-00) and three (8-00A). For version 8-00 / 8-00A, the reflood option usually has been initiated automatically by the code between 25 and 30 seconds after opening of the break valves when the system pressure has fallen below 10 bars and the collapsed liquid level in the core has reached its minimum (see figs. 3.30 and 3.37). For version 8-00T, the reflood option initiation trip has been set externally when the average collapsed liquid level in the core-region reached a value of less than 10%. According to fig. 3.37, this happened for the first time approximately 6 seconds after the initiation of the experiment; this external initiation of the reflood option is independent of the system pressure.

In figs. 3.48 a to k, the cladding temperatures measured at all the 10 axial positions in the center box 5 (hot channel) have been compared to the equivalent two RELAP5/Mod2 calculations; even we have expected the top-down rewetting only at the upper three positions of the core, we have plotted the results at all position investigating whether or not our modifications will influence the results in the lower part of the core too.

At all axial levels, RELAP5/Mod2 results of the 8-00 and 8-00A versions of nodalization have been found identical. The straight curves in all of the plots always cover the dashed lines of the 8-00A version totally.

Small discrepancies may be observed between the calculations of the 8-00/8-00A and the 8-00T versions, i.e. the version with external initiation of the reflood option. The deviations are relatively small in the lower part of the core at levels 02 and 11 (figs. 3.48a and b) and then slightly increase at levels 21 to 29 (figs. 3.48c and g), where the results of

the 8-00T runs indicate a significant decrease of the cladding temperatures of nearly 200 K between 15 and 20 seconds after the initiation of the transient, i.e. immediately after the reflood option has been triggered.

At axial level 43.8 (fig. 3.48h), the 8-00T run of RELAP5/Mod2 has calculated a "top-down quench like" drop of the cladding temperature at approximately 20 second of the transient which is in good agreement with the signals of at least four of the radial distributed thermocouples on axial core level 43.8 (see fig. 3.1c); as we shall remember the reference temperature given in fig. 3.48h is an average of all the thermocouples on this axial level and therefore expresses top down quenching in a rather damped manner.

At even higher core levels (figs. 3.48i and k), no significant core heat-up at all has been calculated by RELAP5/Mod2. Here, as at the bottom of the core, the RELAP5/Mod2 - results using the different versions of nodalization did not deviate dramatically.

In figs. 3.49a to d, the comparison has been made for the calculations of the average channel at the four available core levels of side box 4. Here, both sets of RELAP5/Mod2 calculations (8-00/8-00A and 8-00T) are poor compared to the experimental data (symbols). Whereas the three RELAP5/Mod2 calculations each have been unable to predict the core heat-up during the first 10 to 15 seconds which is significant in the experimental data, the 8-00/8-00A results tended to overpredict the core heat-up during the refill phase of the experiment and the 8-00T results usually have underpredicted them. Generally, by using these three different nodalizations, RELAP5/Mod2 has done an unsatisfactory job.

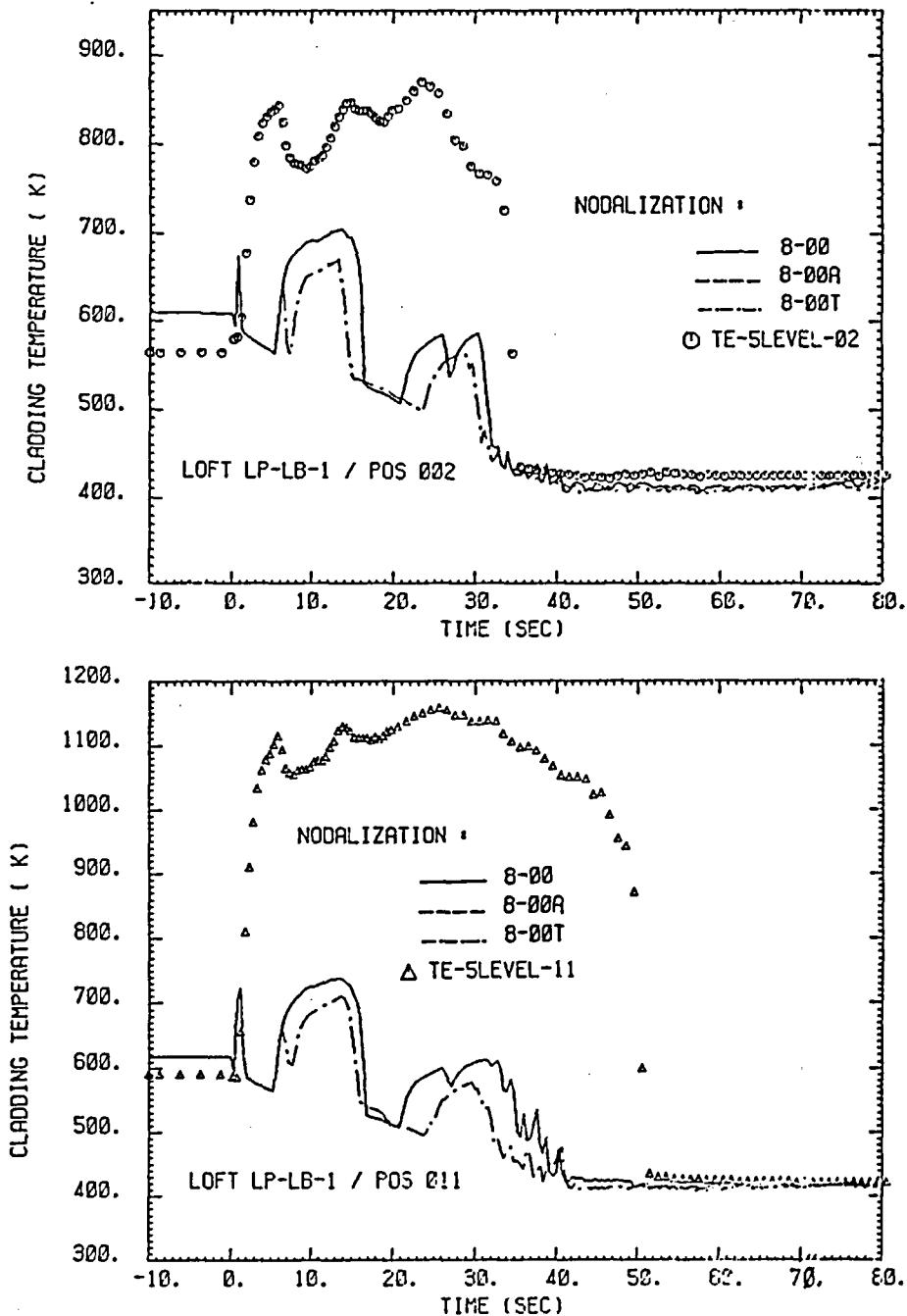


Figure 3.48: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (8-00 / A) and with (8-00T) external triggering of the reflood option
 a) at level-02
 b) at level-11

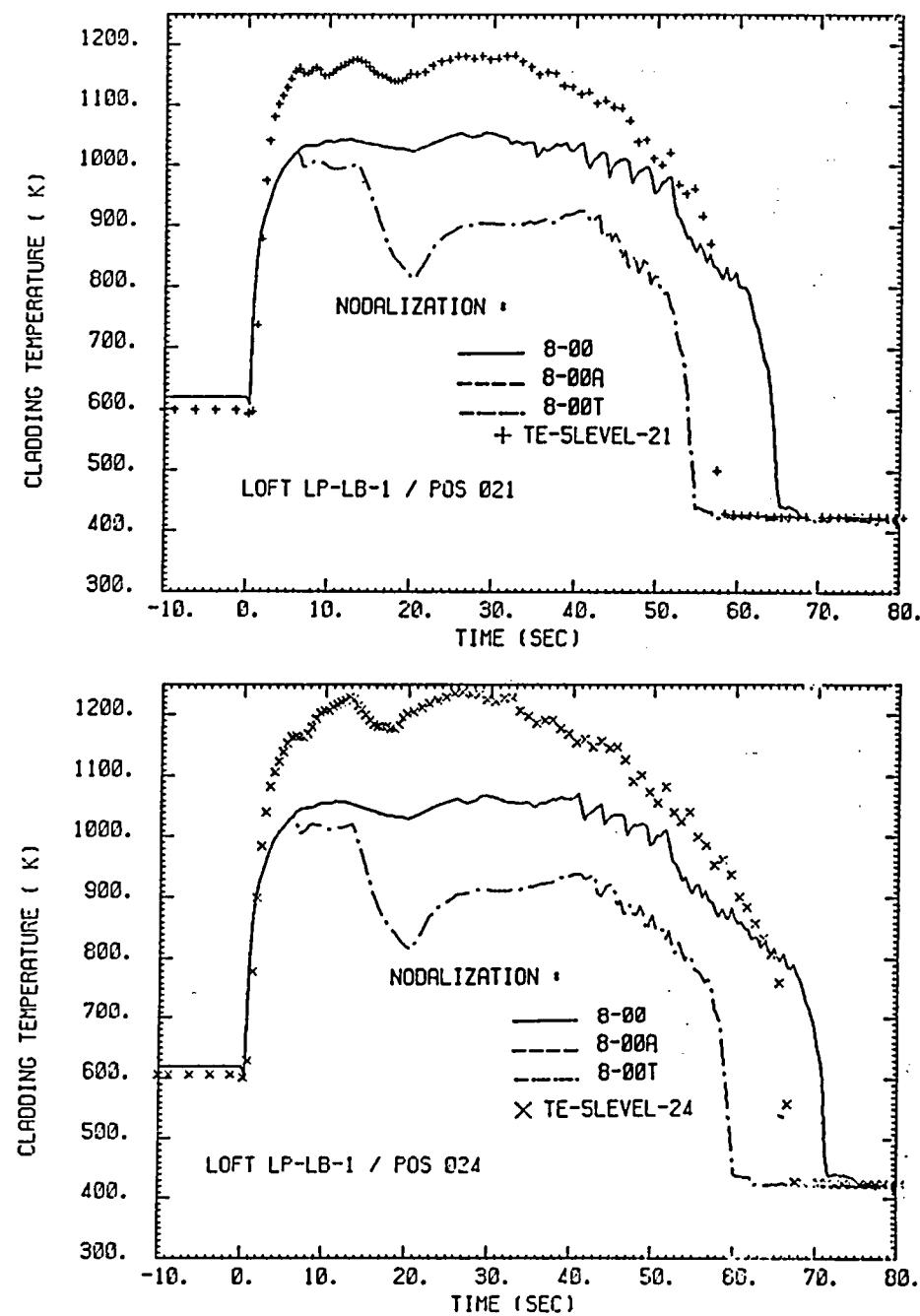


Figure 3.48: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (8-00 / A) and with (8-00T) external triggering of the reflood option

- at level-21
- at level-24

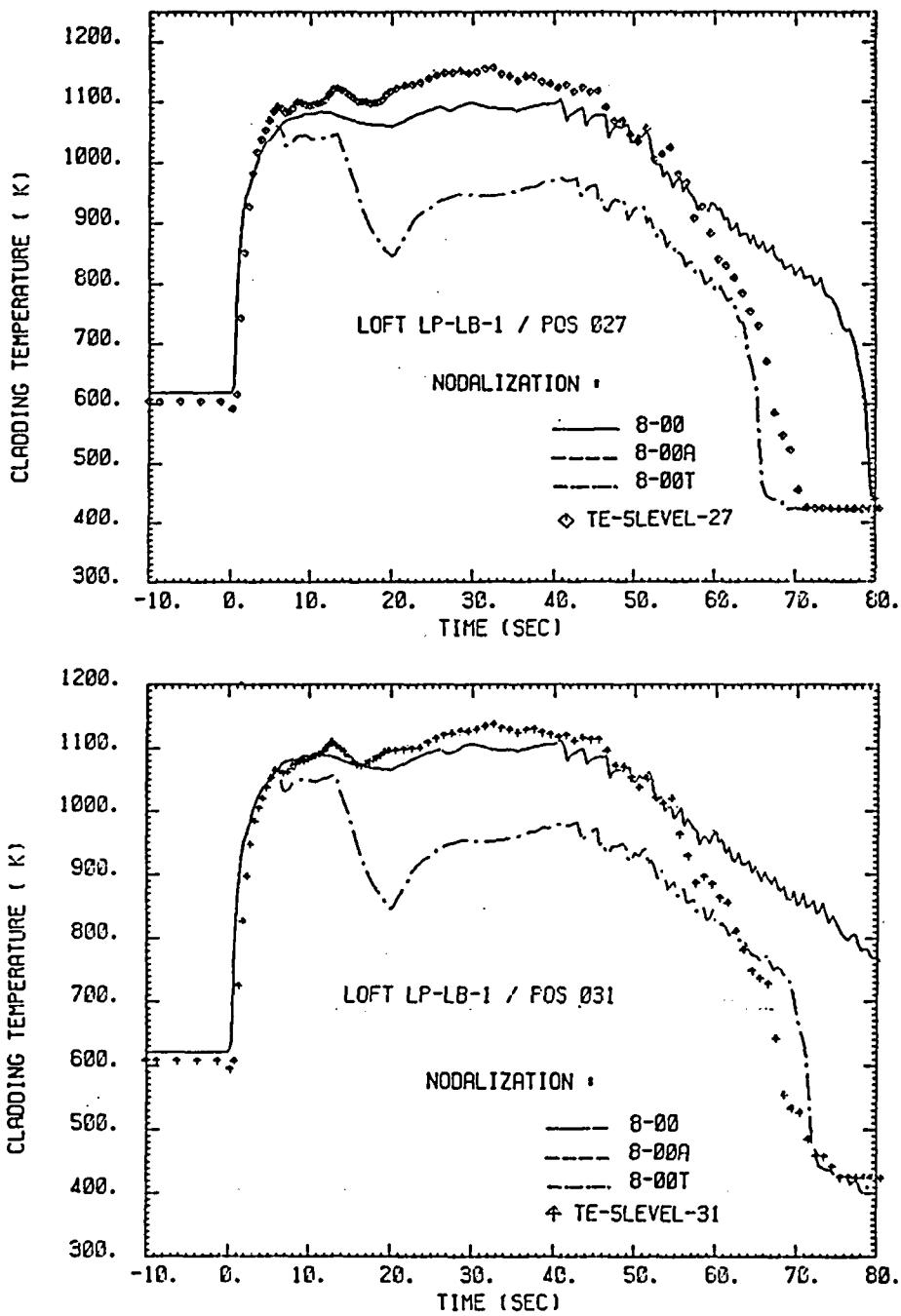


Figure 3.48: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (8-00 / A) and with (8-00T) external triggering of the reflood option

e) at level-27

f) at level-32

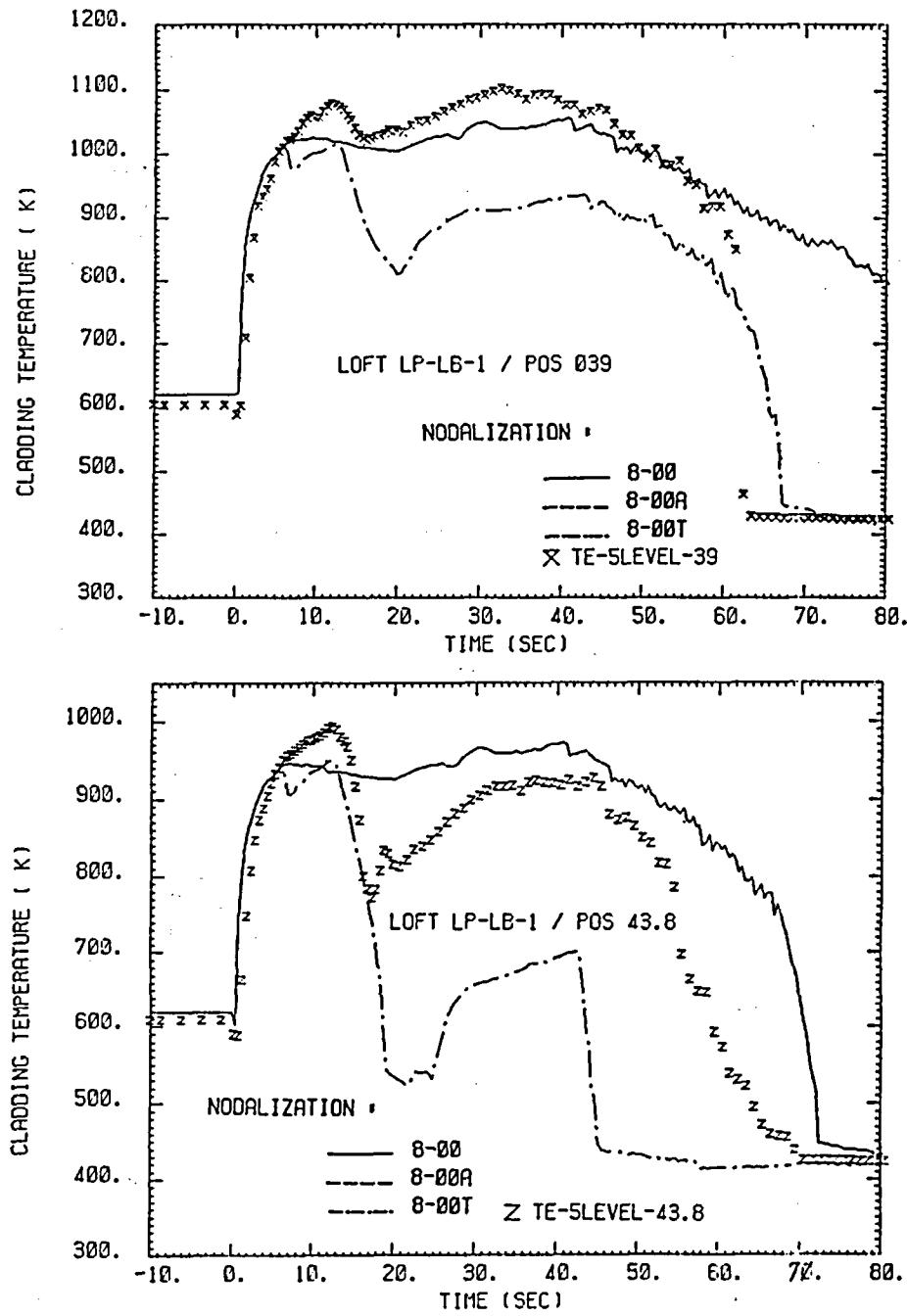


Figure 3.48: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (8-00 / A) and with (8-00T) external triggering of the reflood option
 g) at level-39
 h) at level-43.8

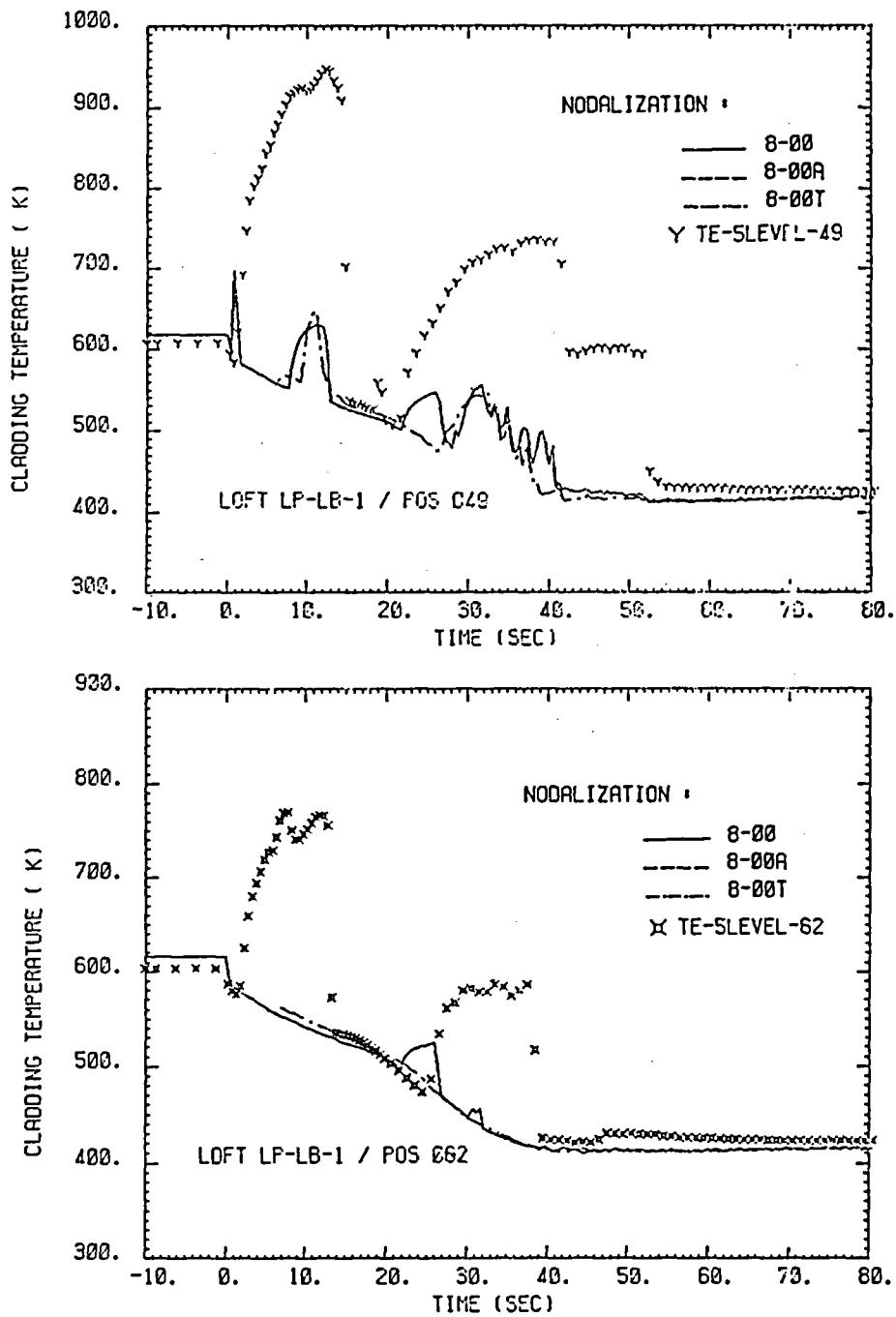


Figure 3.48: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (8-00 / A) and with (8-00T) external triggering of the reflood option

- at level-49
- at level-62

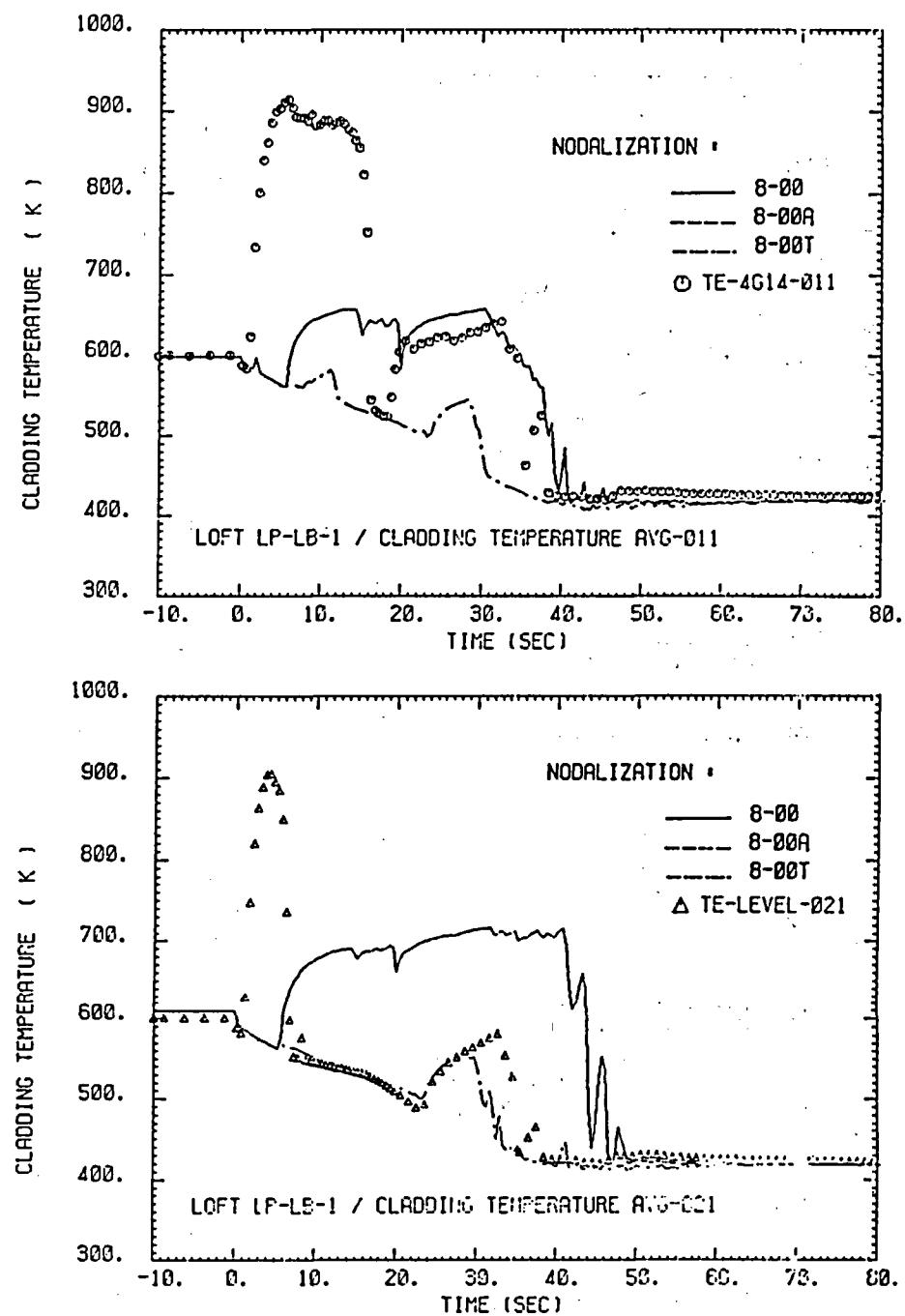


Figure 3.49: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (8-00 /A) and with (8-00T) external triggering of the reflood option

- at level-11 (average channel)
- at level-21 (average channel)

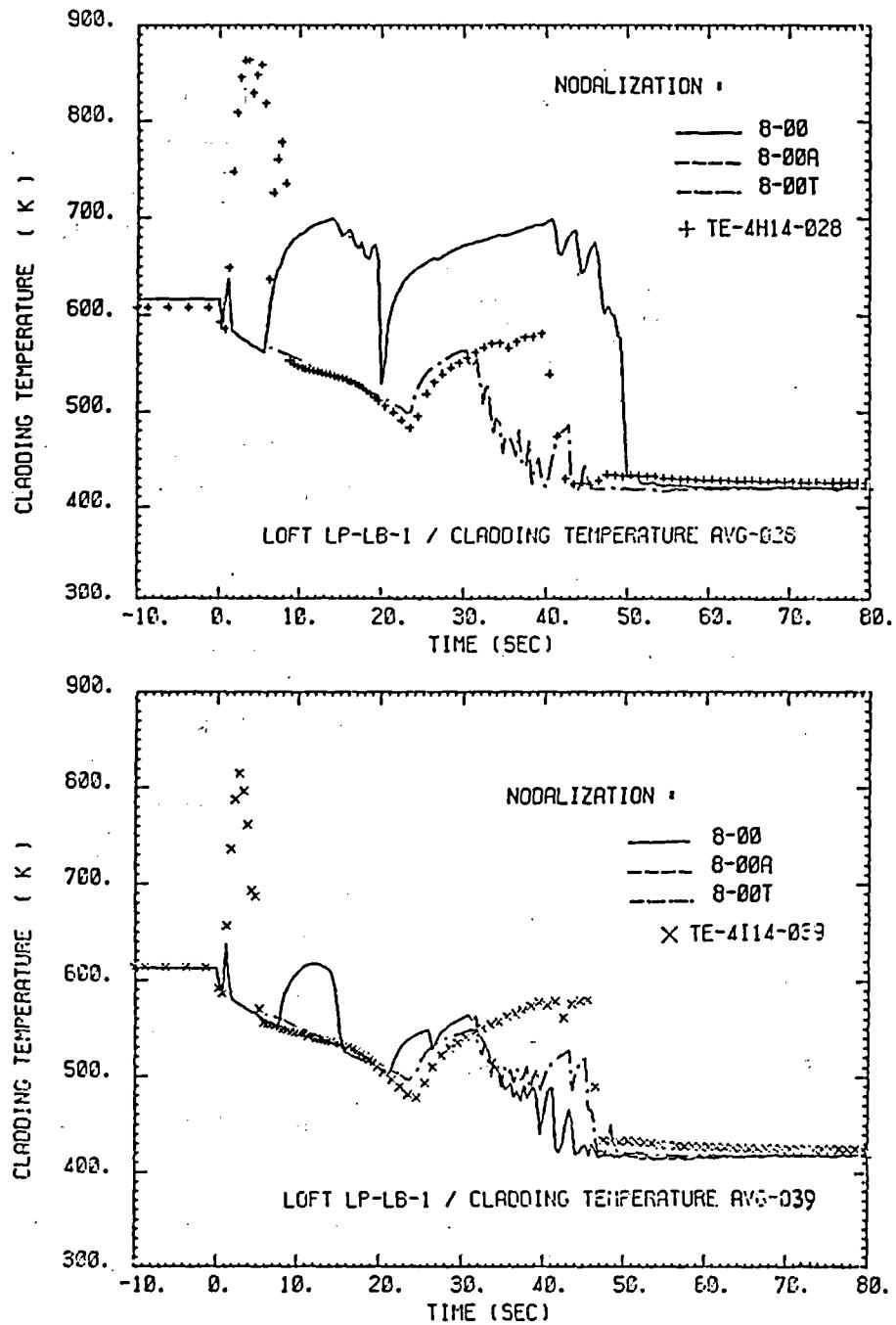


Figure 3.49: Comparison of cladding temperatures calculated by RELAP5/Mod2 without (8-00 / A) and with (8-00T) external triggering of the reflood option

c) at level-28 (average channel)
 d) at level-39 (average channel)

Summarizing our observations with respect to top-down rewetting, one has to conclude that RELAP5/Mod2 generally has not been able to predict this phenomenon. A change in the logic of initiating the reflood option (which forces RELAP5/Mod2 both to use a slightly modified heat transfer package and to subdivide the axial meshing of the cladding as predetermined by the length of the adjacent hydrodynamic volume in order to keep better track of the axial temperature distribution in the vicinity of the quench front) only resulted at one axial level (43.8 inches from the bottom of the core) in a better prediction without explaining the physical phenomena but on the other hand created worse results in other phases of the transient like the "top-down quenching" like drop of the cladding temperatures in the middle of the core which is not supported by the experimental data.

Chapter 4

Conclusions

Experiment LP-LB-1 was conducted on February 3, 1984, in the Loss-Of-Fluid-Test (LOFT) facility at the Idaho National Engineering Laboratory under the auspices of the OECD. It simulated a double-ended offset shear of one inlet pipe in a four loop PWR and was initiated from conditions representative of licensing limits in a PWR. Additional boundary conditions for the simulation were loss of offsite power, rapid primary coolant pump coastdown, and UK minimum safeguard emergency core coolant injection rates.

During this experiment, all fuel rods in the central fuel assembly (box 5) experienced temperatures in excess of 1100 K in their high power regions (about 24 inches from the bottom of the core), whereas the maximum cladding temperatures reached peak values of 1261 K during blowdown and 1257 K during refill/reflood which were the highest temperatures ever measured in LOFT. The core-wide temperature increase continued until a partial core top-down quench occurred, starting at 13 seconds, which affected the top third of the core. This top-down rewetting was one of the key-phenomena of the LOFT experiment LP-LB-1 .

For the plant to be analysed, the "adequate nodalization" is usually unknown and only some very rough criteria can be given to the code user which may make the accuracy of a prediction be strongly related to the

"experience" of the code user, a quite unsatisfactory conclusion. Therefore, we have analysed the LP-LB-1 experiment by using the best estimate code RELAP5/Mod2 cy36-02 with different nodalizations of the LOFT system. Starting with a nodalization similar to the one used by the code developers at INEL (specially developed for small break LOCAs), we have reduced the numbers of volumes, junctions and heat structures in the primary loop of the LOFT system to nearly half whereas the entire vessel stayed unchanged to meet the requirements of the given experimental axial positions, especially for the cladding temperature measurements. We further have investigated on the influence of fine meshing in the core zone during reflooding on quench time and -temperature and on the influence of the time of initialization of the reflood option with respect to RELAP5/Mod2 's predicting capabilities of the rewetting phenomena.

RELAP5/Mod2 , cy36-02 has calculated the general thermo-hydraulic behaviour of experiment LP-LB-1 satisfactorily although it failed in describing the top-down rewetting which happened in the upper third of the core between 15 and 20 seconds of the transient (blowdown phase). Independently of the chosen nodalization, most of the investigated parameters like pressures, mass flows in the broken and intact loops, pump speed

and ECC systems have error bounds less than $\pm 20\%$ but the cladding temperatures usually have been underpredicted between 10 and up to 150 K (hot spot). We believe that the, generally spoken, relatively good agreement of most of the RELAP5/Mod2 results with the measured LOFT data is not really surprising because codes like RELAP5/Mod2 have been extensively used for analysing LOFT experiments and LOFT results have been extensively used to eliminate insufficiencies both in the codes themselves as well as in the more plant specific nodalization of the problem. Therefore, even if these "adjustments" have been mainly made for small break LOCAs, one has to be aware of the fact that both the code and the LOFT specific nodalization (also used here as the basic nodalization scheme), are somehow "LOFT tuned" which resulted in these quite acceptable results.

We may summarize our findings in the following points :

- With respect to the computation time, the degree of specification of the nodalization, i.e. the numbers of volumes and junctions, is of course an important parameter. But not always a lower number of junctions and volumes automatically has lead to a faster calculation. Sometimes, with respect to computing time and because of numerical instabilities, the profit of a much reduced nodalization is rather small.
- The cladding temperatures usually have been underpredicted between 10 and up to 150 K (hot spot). In addition, for all nodalizations, the hot spot has been calculated at a position more downstream of the core; instead at the experimentally inferred position 24 inches from the bottom of the core, RELAP5/Mod2 always

calculated the hot spot at axial level 31.

- For large break LOCAs, the nodalization seems to be important only for the cladding temperatures, where significant differences can be observed for the different nodalizations under investigation. Especially, the times of final quench differ from nodalization to nodalization some 20 to 30 seconds.
- For the other parameters, the deviations between the results of the calculations with the different nodalizations under investigation have error bound of less than $\pm 20\%$, but surprisingly, the results of runs with less detailed nodalizations usually seem to be closer to the experimental data than the ones with the more detailed basic nodalization scheme which is similar to the original EG&G nodalization of LOFT.
- A negative influence on the RELAP5/Mod2 calculations seems to have the modeling of the stored energy of the vessel material, especially on the time of final quenching. When taking into account the heat capacity of the down-comer walls as well as of some entire core material (version "C" of nodalization), the predictions have been found to be poorer than by neglecting these effects.
- The modeling of the fuel rod, i.e. the number of radial meshes, has been found to have an important influence both on the cladding temperatures as well as on the center fuel temperatures. Compared to the equivalent results obtained using the other nodalizations, the temperature traces of the 8-10 and 8-10C results (reduction of the number of radial meshes from 10 to 5 (hot) and from 5 to 4 (avg.))

differ quite significantly at very low and very high core elevations, but influence of the nodalization used on the other thermodynamic parameters is small.

- The influence of the allowed fine meshing during the reflooding on the code predictions seems to be small when we compare e.g. the results of the 6-00 (only 2 fine meshes in the hot channel) with those of the 6-01 nodalization (32 fine meshes).
- The time point of initiating the reflood option determines the “quench behaviour” of the code because it starts the fine-meshing in the core-zone thus enabling a more correct tracing of the axial cladding temperature distribution and consequently a better reflood modeling. Therefore, the comparison three possible methods of initiating the reflood option have manifested a strong dependence of the results on this settings.
 - The results of RELAP5/Mod2 runs using one of the two code-internal trips for the initiation of the reflood option are identical.
 - An external trip based on the fluid level in the core alone has lead to much lower values of the cladding temperatures at nearly all axial levels of the LOFT core but still was not able to correctly calculate the top-down rewetting in the upper third of the core (the “good” results at level 43.8 seems to us to be a little bit coincidental).
- Finally, a remarkable inconsistency has been observed concerning the heat transfer and flow regime logics of RELAP5/Mod2 . During the refill phase of the calculation, at the same time

RELAP5/Mod2 assumed different flow regimes on one side for its calculation of the interfacial shear stresses and interfacial heat transfers and on the other side for the determination of the heat transfer from the wall to the fluid (liquid). This unphysical modeling of the thermo-hydraulic conditions in the core region of the LOFT reactor may invalidate even results which have been proved as to be satisfactory by a pure comparison with the experimental data, e.g. at the same axial position and at the same time, RELAP5/Mod2 assumed both wet and dry surface by defining mist flow and slug flow for the same volume.

Chapter 5

Appendices

5.1 References

- [1] Reeder, D.G. : LOFT System and Test Description
NUREG/CR-0247 Tree-1208 (1978, update 9/80)
- [2] Ybaronndo, et.al. : Examination oft LOFT Scaling
74-WA-HT-53, ANS proceedings, New York (1974)
- [3] Adams, J.P.; Birchley, J.C. : Quick Look Report
on OECD LOFT-Experiment LP-LB-1
OECD LOFT-T-3504, EG&G Idaho Inc. (1984)
- [4] Andreani, M and Grütter, H.P : Post-Test Analysis of
OECD LOFT-Experiment LP-SB-3 by RELAP5/Mod2
EIR internal report TM-32-85-18 (1985)
- [5] Lorenzini, E; Orlandelli, C.M. and Spada, A : LOFT LP-LB-1
Post-Test Analysis using RELAP5/Mod1 computer
code
ENEA Safety Research Program (1984)
- [6] Ransom, V.H.; et.al. : RELAP5/Mod2 Code Manual
NUREG/CR-4312 (1985)
- [7] Lübbesmeyer, D. : Post-Test-Analysis of OECD LOFT Experiment LP-02-6
with RELAP5/Mod2 -cy36-02
NUREG/IA-00086 (1991)

- [8] Anonymous : OECD LOFT Experiment LP-LB-1 : Tape Descriptions and Supplementary Information-
- [9] Brittain, I. and Aksan, S.N. : OECD-LOFT Large Break LOCA Experiments : Phenomenology and Computer Code Analyses
PSI-report 72 (or AEEW-TRS-1003), August 1990

5.2 Listing of RELAP5/Mod2 - Input Mk. 6-00C

Finally, as an example, the RELAP5/Mod2 - inputdeck Mk. 6-00C will be listed (for the "Normal Version", lines LB1-1729 to LB1-1876 and lines LB1-2242 to LB1-2280 have to be deleted) :

```

*                                         LB1-   1
= LOFT LP-LB-1 [post test analysis] / mk 6-00C (13.4.87) *LB1-   2
*                                         LB1-   3
*     LP-LB-1 initial conditions LB1-   4
*                                         LB1-   5
*             power = 49.3 MW LB1-   6
*             pcs flow = 305.8 kg/s LB1-   7
*             t hot = 585.8 K LB1-   8
*             tcold = 556.0 K LB1-   9
*             pcs pressure = 14.95 MPascal LB1-  10
*                                         LB1-  11
*             pzc pressure = 14.82 MPascal LB1-  12
*             pzc level = 1.04 m (41 in) LB1-  13
*                                         LB1-  14
*                                         LB1-  15
*                                         LB1-  16
* nodalisation LB1-  17
* -----
* corebereich thermoelement-lokationen angepasst. LB1-  19
* 13 volumen in hot- und 5 in average channel. LB1-  20
* core-aufteilung hotchann.-averagechann.-bypass 82 - 14 - 4 LB1-  21
* core-aufteilung pins    1081    219 LB1-  22
*                                         LB1-  23
* heat structures fur downcomer und corebarrel. LB1-  24
*                                         LB1-  25
*                                         LB1-  26
***** LB1-  27
****** LB1-  28
*                                         LB1-  29
00000100 new      transnt *LB1-  30
00000101 run      *LB1-  31
00000105 5.0      10.0      850. *LB1-  32
00000110 nitrogen *LB1-  33
*
* time step control cards          * required LB1-  35
* end time min dt max dt optn mnr mjr rst LB1-  36
00000201 10.      1.0-6     .2      15003   10    1000 1000 *LB1-  37

```


00000328	tempf	100010000	*LB1- 81
00000329	tempg	100010000	*LB1- 82
00000330	p	100010000	*LB1- 83
00000331	p	420010000	*LB1- 84
*			LB1- 85
00000332	cntrlvar	460	*LB1- 86
00000333	cntrlvar	461	*LB1- 87
00000334	cntrlvar	462	*LB1- 88
00000335	cntrlvar	463	*LB1- 89
00000336	cntrlvar	464	*LB1- 90
*			LB1- 91
00000337	mflowj	610000000	*LB1- 92
00000338	cntrlvar	4	*LB1- 93
00000339	p	620010000	*LB1- 94
00000340	mflowj	630000000	*LB1- 95
*			LB1- 96
00000341	p	240010000	*LB1- 97
00000342	voidf	240010000	*LB1- 98
00000343	cntrlvar	240	*LB1- 99
00000344	voidf	225010000	*LB1- 100
00000345	voidf	210020000	*LB1- 101
00000346	velfj	225020000	*LB1- 102
00000347	cntrlvar	444	*LB1- 103
00000348	cntrlvar	454	*LB1- 104
00000349	cntrlvar	90	*LB1- 105
00000350	cntrlvar	91	*LB1- 106
00000351	cntrlvar	93	*LB1- 107
00000352	cntrlvar	98	*LB1- 108
00000353	voidg	231010000	*LB1- 109
00000354	voidg	231020000	*LB1- 110
00000355	voidg	231040000	*LB1- 111
00000356	voidg	231050000	*LB1- 112
00000357	voidg	231060000	*LB1- 113
00000358	voidg	231070000	*LB1- 114
00000359	voidg	231090000	*LB1- 115
00000360	voidg	231100000	*LB1- 116
00000361	voidg	231110000	*LB1- 117
00000362	voidg	231130000	*LB1- 118
00000363	cntrlvar	470	*LB1- 119
*			LB1- 120
00000364	tempf	202010000	*LB1- 121
00000365	tempf	210020000	*LB1- 122
00000366	tempf	210030000	*LB1- 123

00000367	tempf	210040000	*LB1- 124
00000368	tempf	220010000	*LB1- 125
*			LB1- 126
00000369	httemp	231000110	*LB1- 127
00000370	httemp	231000210	*LB1- 128
00000371	httemp	231000410	*LB1- 129
00000372	httemp	231000510	*LB1- 130
00000373	httemp	231000610	*LB1- 131
00000374	httemp	231000710	*LB1- 132
00000375	httemp	231000910	*LB1- 133
00000376	httemp	231001010	*LB1- 134
00000377	httemp	231001110	*LB1- 135
00000378	httemp	231001310	*LB1- 136
*			LB1- 137
00000379	httemp	231000601	*LB1- 138
00000380	httemp	231001001	*LB1- 139
*			LB1- 140
00000381	httemp	230000105	*LB1- 141
00000382	httemp	230000205	*LB1- 142
00000383	httemp	230000305	*LB1- 143
00000384	httemp	230000405	*LB1- 144
*			LB1- 145
00000385	cntrlvar	2	*LB1- 146
00000386	cntrlvar	230	*LB1- 147
00000387	cntrlvar	231	*LB1- 148
00000388	cntrlvar	250	*LB1- 149
00000389	cntrlvar	76	*LB1- 150
*			LB1- 151
00000390	mflowj	245020000	*LB1- 152
00000391	mflowj	201000000	*LB1- 153
00000392	mflowj	205000000	*LB1- 154
00000393	mflowj	271000000	*LB1- 155
00000394	mflowj	275000000	*LB1- 156
*			LB1- 157
*			LB1- 158
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*			LB1- 159
*			LB1- 160
* trips			LB1- 161
*			LB1- 162
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*			LB1- 163
*			LB1- 164
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----			LB1- 165
* [t-500] end of job trip			LB1- 166

```

*---- -----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 167
00000500 time 0 ge null 0 90. 1 *LB1- 168
00000600 500 *LB1- 169
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 170
*
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 171
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 172
* 510-515 test specific trips LB1- 173
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 174
* break opens LB1- 175
00000510 time 0 ge null 0 10.0 1 *LB1- 176
*
*
* scram LB1- 177
00000511 time 0 ge timeof 510 0.13 1 *LB1- 180
* pcp trip LB1- 181
00000512 time 0 ge timeof 510 0.6 1 *LB1- 182
* lpis on LB1- 183
00000513 time 0 ge timeof 510 32.0 1 *LB1- 184
* broken leg bypass LB1- 185
00000514 time 0 ge null 0 1.0+9 1 *LB1- 186
* accumulator valve LB1- 187
00000515 time 0 ge timeof 510 17.5 1 *LB1- 188
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 189
*
* different related trips LB1- 190
*
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 191
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 192
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 193
* lt 681 ecc check valve card 6000301 LB1- 194
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 195
00000577 mflowj 600000000 ge null 0 0.0 n *LB1- 196
00000578 p 605010000 gt p 185010000 0. n *LB1- 197
00000681 577 and 578 n *LB1- 198
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 199
* lt 682 accumulator valve card 6100301 LB1- 200
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 201
00000582 cntrlvar 4 lt null 0 1.0-4 1 *LB1- 202
00000682 -582 and 515 n *LB1- 203
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 204
* lt 685-686 steam valve card 5400301 LB1- 205
*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 206
* open trip LB1- 207
00000589 p 530010000 gt null 0 5.55+6 n *LB1- 208
00000590 p 530010000 lt null 0 5.50+6 n *LB1- 209

```


* pressurizer connection tee reactor vessel side	LB1- 253
*---- 1---- 1---- 1---- 1---- 1---- 1---- 1---- 1----	LB1- 254
1050000 "pqr t rv" branch	*LB1- 255
1050001 1 0	*LB1- 256
1050101 0.0634444 1.0531192 0.0 0.0 0.0 0.0	*LB1- 257
1050102 4.0e-5 0.0 00	*LB1- 258
1050200 0 1.48614+7 1386879. 2462922. 0.	*LB1- 259
1051101 105010000 107000000 0.0 0.12 0.12 0000	*LB1- 260
1051201 7.0344353 7.0361328 0. * (M = 304.54 kg/s)	LB1- 261
*---- 1---- 1---- 1---- 1---- 1---- 1---- 1----	LB1- 262
* pressurizer connection tee	LB1- 263
*---- 1---- 1---- 1---- 1---- 1---- 1---- 1----	LB1- 264
1070000 "pqr " branch	*LB1- 265
1070001 1 0	*LB1- 266
1070101 0.0620253 0.2810215 0.0 0.0 0.0 0.0	*LB1- 267
1070102 4.0e-5 0.0 00	*LB1- 268
1070200 0 1.48580+7 1386884. 2462992. 0.	*LB1- 269
1071101 107010000 110000000 0.0 0.135 0.135 0000	*LB1- 270
1071201 7.1995277 7.1999016 0. * (M = 304.55 kg/s)	LB1- 271
*---- 1---- 1---- 1---- 1---- 1---- 1----	LB1- 272
* pressurizer connection tee steam generator side	LB1- 273
*---- 1---- 1---- 1---- 1---- 1---- 1----	LB1- 274
1100000 "pqr t sg" branch	*LB1- 275
1100001 1 0	*LB1- 276
1100101 0.0606063 0.9207292 0.0 0.0 0.0 0.0	*LB1- 277
1100102 4.0e-5 0.0 00	*LB1- 278
1100200 0 1.48543+7 1386887. 2463072. 0.	*LB1- 279
1101101 110010000 112000000 0.0 0.15 0.15 0000	*LB1- 280
1101201 7.6043472 7.6044426 0. * (M = 304.55 kg/s)	LB1- 281
*---- 1---- 1---- 1---- 1---- 1---- 1----	LB1- 282
* hot leg piping	LB1- 283
*---- 1---- 1---- 1---- 1---- 1---- 1----	LB1- 284
1120000 "hotleg p" pipe	*LB1- 285
1120001 2	*LB1- 286
1120101 0.0 2	*LB1- 287
1120201 0.0 1	*LB1- 288
1120301 1.38893 1	*LB1- 289
1120302 0.707687 2	*LB1- 290
1120401 0.0796973 1	*LB1- 291
1120402 0.0579614 2	*LB1- 292
1120501 0.0 2	*LB1- 293
1120601 0.0 1	*LB1- 294
1120602 90.0 2	*LB1- 295

1120701	0.0	1	*LB1-	296					
1120702	0.246447	2	*LB1-	297					
1120801	4.0e-5	0.0	2	*LB1-	298				
1120901	0.20	0.20	1	*LB1-	299				
1121001	00	2		*LB1-	300				
1121101	0000	1		*LB1-	301				
1121201	0	1.48481+7	1386890.	2463202.	0.	0.	1	*LB1-	302
1121202	0	1.48527+7	1386893.	2463106.	0.	0.	2	*LB1-	303
1121300	0							*LB1-	304
1121301	7.6044426	7.6044197	0.	1	*	(M = 304.55 kg/s)		LB1-	305
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	306
* sg inlet plenum									
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	307
1140000	"sg in pl"		branch					*LB1-	308
1140001	2	0						*LB1-	309
1140101	0.0	0.629795	0.33532	0.0	90.	0.512756		*LB1-	310
1140102	4.e-5	0.0102	00					*LB1-	311
1140200	0	1.48161+7	1386901.	2463878.	0.			*LB1-	312
1141101	112010000	114000000	0.0512	0.0	0.0	0100		*LB1-	313
1142101	114010000	115000000	0.0	0.0	0.0	0100		*LB1-	314
1141201	5.3275757	5.3275909	0.	*	(M = 304.55 kg/s)			LB1-	315
1142201	2.8866138	2.8866138	0.	*	(M = 304.55 kg/s)			LB1-	316
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	317
* sg u-tubes									
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	318
1150000	"sg tubes"		pipe					*LB1-	319
1150001	8							*LB1-	320
1150101	0.0	8						*LB1-	321
1150201	0.151171	7						*LB1-	322
1150301	0.902	1						*LB1-	323
1150302	0.6096	3						*LB1-	324
1150303	0.462908	5						*LB1-	325
1150304	0.6096	7						*LB1-	326
1150305	0.902	8						*LB1-	327
1150401	0.136356	1						*LB1-	328
1150402	0.0921538	3						*LB1-	329
1150403	0.0699783	5						*LB1-	330
1150404	0.0921538	7						*LB1-	331
1150405	0.136356	8						*LB1-	332
1150501	0.0	8						*LB1-	333
1150601	90.0	4						*LB1-	334
1150602	-90.0	8						*LB1-	335
1150701	0.902	1						*LB1-	336

1250102	4.0e-5	0.0	00				*LB1- 425
1250200	0	1.47662+7	1226488.	2464932.	0.		*LB1- 426
1251101	125010000	130000000	0.0	0.13	0.13	0000	*LB1- 427
1251201	4.8336296	4.8336296	0.	*	(M = 142.42 kg/s)		LB1- 428
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 429
* pump 1 inlet							LB1- 430
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 431
1300000	"pmp1 in"		snglvol				*LB1- 432
1300101	0.0	0.457201	0.0177444	0.0	90.	0.457201	*LB1- 433
1300102	4.0e-5	0.0	00				*LB1- 434
1300200	0	1.47556+7	1226490.	2465156.	0.		*LB1- 435
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 436
* primary coolant pump 1							LB1- 437
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 438
1350000	"pump1"		pump				*LB1- 439
1350101	.0366	0.0	0.0991	0.0	90.	0.317900	*LB1- 440
1350102	0						*LB1- 441
1350108	130010000	0.0	0.017	0.017	0000		*LB1- 442
1350109	140000000	0.0	0.05	0.05	0000		*LB1- 443
1350200	0	1.48526+7	1226604.	2463108.	0.		*LB1- 444
1350201	0	5.1256828	5.1256828	0.	*	(M = 142.42 kg/s)	LB1- 445
1350202	0	5.1253471	5.1253471	0.	*	(M = 142.42 kg/s)	LB1- 446
1350301	0	0	-1	-1	512	0	*LB1- 447
1350302	369.	0.5506231	.3155	96.	500.6	1.431	*LB1- 448
*	^	(pump speed = 203.17993 rev/s)					LB1- 449
1350303	613.6	0.	207.433	.0444	19.5987	0.	*LB1- 450
1350310	0.0	0.0	0.0				*LB1- 451
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 452
* pump 1 outlet pump side							LB1- 453
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 454
1400000	"pmp1 out"		snglvol				*LB1- 455
1400101	0.0	0.502185	0.0183849	0.0	0.0	0.0	*LB1- 456
1400102	4.0e-5	0.0	00				*LB1- 457
1400200	0	1.49520+7	1226608.	2461010.	0.		*LB1- 458
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 459
* pmp1 outlet pipe tee side							LB1- 460
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 461
1450000	"pmp1 ote"		branch				*LB1- 462
1450001	2	0					*LB1- 463
1450101	0.0	1.40843	0.0633861	0.0	0.0	0.0	*LB1- 464
1450102	4.0e-5	0.0	00				*LB1- 465
1450200	0	1.49550+7	1226613.	2460944.	0.		*LB1- 466
1451101	140010000	145000000	0.0	0.0	0.0	0000	*LB1- 467

1452101	145010000	150000000	0.0	0.57456	0.050347	0000	*LB1-	468	
1451201	5.1233711	5.1233711	0.	* (M = 142.42 kg/s)			LB1-	469	
1452201	4.1676712	4.1676712	0.	* (M = 142.42 kg/s)			LB1-	470	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	471	
* pump outlet tee									
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	472	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	473	
1500000	"pmp oute"	branch					*LB1- 474		
1500001	1	0					*LB1-	475	
1500101	0.0	0.496511	0.0316011	0.0	0.0	0.0	*LB1-	476	
1500102	4.0e-5	0.0	00				*LB1-	477	
1500200	0	1.49424+7	1226616.	2461222.	0.		*LB1-	478	
1501101	150010000	175000000	0.063427	0.0	0.0	0000	*LB1-	479	
1501201	6.3237686	6.3237686	0.	* (M = 304.55 kg/s)			LB1-	480	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	481	
* pump 2 suction tee outlet									
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	482	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	483	
1550000	"pmp2 sct"	branch					*LB1- 484		
1550001	1	0					*LB1-	485	
1550101	0.0	1.00308	0.0640548	0.0	90.	0.520704	*LB1-	486	
1550102	4.0e-5	0.0	00				*LB1-	487	
1550200	0	1.47641+7	1226488.	2464976.	0.		*LB1-	488	
1551101	155010000	160000000	0.0	0.13	0.13	0000	*LB1-	489	
1551201	5.5026512	5.5026512	0.	* (M = 162.13 kg/s)			LB1-	490	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	491	
* pump 2 inlet pipe									
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	492	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	493	
1600000	"pmp2 in"	snglvol					*LB1- 494		
1600101	0.0	0.457201	0.0177444	0.0	90.	0.457201	*LB1-	495	
1600102	4.0e-5	0.0	00				*LB1-	496	
1600200	0	1.47515+7	1226489.	2465244.	0.		*LB1-	497	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	498	
* primary coolant pump 2									
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	499	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-	500	
1650000	"pump2"	pump					*LB1- 501		
1650101	.0366	0.0	0.0991	0.0	90.	0.317900	*LB1-	502	
1650102	0						*LB1-	503	
1650108	160010000	0.0	0.017	0.017	0000		*LB1-	504	
1650109	170000000	0.0	0.1	0.1	0000		*LB1-	505	
1650200	0	1.48496+7	1226611.	2463170.	0.		*LB1-	506	
1650201	0	5.8351479	5.8351479	0.	* (M = 162.13 kg/s)			LB1-	507
1650202	0	5.8347816	5.8347816	0.	* (M = 162.13 kg/s)			LB1-	508
1650301	135	135	135	-1	-1	512	0	*LB1- 509	
1650302	369.		0.5831434	.3155	96.	500.6	1.431	*LB1- 510	

* ^{..} (pump speed = 215.17993 rev/s) LB1- 511
 1650303 613.6 0. 207.433 .0444 19.5987 0. *LB1- 512
 1650310 0.0 0.0 0.0
 *---- 1---- 1---- 1---- 1---- 1---- 1---- 1---- 1---- LB1- 514
 * pump 2 outlet LB1- 515
 *---- 1---- 1---- 1---- 1---- 1---- 1---- 1---- LB1- 516
 1700000 "pmp2 out" branch *LB1- 517
 1700001 1 0
 1700101 0.0 0.514071 0.0192958 0.0 0.0 0.0 *LB1- 519
 1700102 4.0e-5 0.0 00
 1700200 0 1.49504+7 1226615. 2461048. 0. *LB1- 521
 1701101 170010000 150000000 0.036611 0.3847 0.6316 0000 *LB1- 522
 1701201 5.8323326 5.8323326 0. * (M = 162.13 kg/s) LB1- 523
 *---- 1---- 1---- 1---- 1---- 1---- 1---- 1---- LB1- 524
 * intact loop cold leg pipe LB1- 525
 *---- 1---- 1---- 1---- 1---- 1---- 1---- 1---- LB1- 526
 1750000 "ilcl pip" pipe *LB1- 527
 1750001 2
 1750101 0.0 2
 1750201 0.0 1
 1750301 0.558577 1
 1750302 0.613244 2
 1750401 0.035428 1
 1750402 0.038895 2
 1750501 0.0 2
 1750601 0.0 2
 1750701 0.0 2
 1750801 4.0e-5 0.0 2
 1750901 0.0 0.0 1
 1751001 00 2
 1751101 0000 1
 1751201 0 1.49419+7 1226617. 2461232. 0. 0. 1 *LB1- 542
 1751202 0 1.49415+7 1226619. 2461240. 0. 0. 2 *LB1- 543
 1751300 0
 1751301 6.3239746 6.3239746 0. 1 * (M = 304.55 kg/s) LB1- 545
 *---- 1---- 1---- 1---- 1---- 1---- 1---- 1---- LB1- 546
 * ecc connection tee LB1- 547
 *---- 1---- 1---- 1---- 1---- 1---- 1---- 1---- LB1- 548
 1800000 "ecc tee" branch *LB1- 549
 1800001 1 0
 1800101 0.0 1.15189 0.0730598 0.0 0.0 0.0 *LB1- 551
 1800102 4.0e-5 0.0 00
 1800200 0 1.49409+7 1226623. 2461252. 0. *LB1- 553

1801101	175010000	180000000	0.0	0.0	0.0	0000	*LB1- 554
1801201	6.3239784	6.3239784	0.	*	(M = 304.55 kg/s)		LB1- 555
*-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	LB1- 556
* reactor vessel nozzle - intact loop cold leg							LB1- 557
*-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	LB1- 558
1850000	"rvn ilcl"	branch					*LB1- 559
1850001	2	0					*LB1- 560
1850101	0.0	1.00965	0.0644920	0.0	0.0	0.0	*LB1- 561
1850102	4.0e-5	0.0	00				*LB1- 562
1850200	0	1.49404e7	1226626.	2461262.	0.		*LB1- 563
1851101	185010000	202000000	0.0634	2.8	2.8	0001	*LB1- 564
1852101	180010000	185000000	0.0	0.0	0.0	0000	*LB1- 565
1852101	6.3264885	6.3264885	0.	*	(M = 304.55 kg/s)		LB1- 566
1852201	6.3238869	6.3238869	0.	*	(M = 304.55 kg/s)		LB1- 567
*							LB1- 568
*							LB1- 569
\$\$\$\$\$\$\$\$\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*							LB1- 570
*							LB1- 571
* reactor vessel [200]							LB1- 572
*							LB1- 573
\$\$\$\$\$\$\$\$\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*							LB1- 574
*							LB1- 575
*-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	LB1- 576
* inlet annulus upper volume intact side							LB1- 577
*-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	LB1- 578
2000000	"inanupri"	annulus					*LB1- 579
2000001	1						*LB1- 580
2000101	0.1308530	1					*LB1- 581
2000301	0.1876129	1					*LB1- 582
2000401	0.0	1					*LB1- 583
2000501	0.0	1					*LB1- 584
2000601	90.0	1					*LB1- 585
2000801	3.81e-6	0.172	1				*LB1- 586
2001001	00	1					*LB1- 587
2001201	0	1.49102e7	1226631.	2461894.	0.	0.	1 *LB1- 588
*-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	LB1- 589
* junction - upper to lower inlet annulus intact side							LB1- 590
*-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	LB1- 591
2010000	"inanmuin"	sngljun					*LB1- 592
2010101	202000000	200000000	0.129467	0.0000	0.0000	0100	*LB1- 593
2010201	0	0.8944483	0.8944483	0.	*	(M = 88.864 kg/s)	LB1- 594
*-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	-----1---	LB1- 595
* inlet annulus middle volume intact side							LB1- 596

*-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 597
 2020000 "inanmidi" annulus *LB1- 598
 2020001 1 *LB1- 599
 2020101 0.1308530 1 *LB1- 600
 2020301 0.2851823 1 *LB1- 601
 2020401 0.0 1 *LB1- 602
 2020501 0.0 1 *LB1- 603
 2020601 -90.0 1 *LB1- 604
 2020801 3.81-6 0.172 1 *LB1- 605
 2021001 00 1 *LB1- 606
 2021201 0 1.49124+7 1226627. 2461850. 0. 0. 1 *LB1- 607
 *-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 608
 * junction - middle to lower inlet annulus intact side LB1- 609
 *-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 610
 2050000 "inanmlin" sngljun *LB1- 611
 2050101 202010000 210000000 0.0709408 0.0 0.0 0100 *LB1- 612
 2050201 0 2.1709213 2.1709213 0. * (M = 215.68 kg/s) LB1- 613
 *-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 614
 * inlet annulus lower volume intact side LB1- 615
 *-----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 616
 2100000 "int down" annulus *LB1- 617
 2100001 4 *LB1- 618
 2100101 0.1464354 1 *LB1- 619
 2100102 0.0 4 *LB1- 620
 2100201 0.0709408 3 *LB1- 621
 2100301 0.2525361 1 *LB1- 622
 2100302 1.5200561 2 *LB1- 623
 2100303 1.2616333 3 *LB1- 624
 2100304 1.0792591 4 *LB1- 625
 2100401 0.0 1 *LB1- 626
 2100402 0.1581866 2 *LB1- 627
 2100403 0.1217000 3 *LB1- 628
 2100404 0.0986806 4 *LB1- 629
 2100501 0.0 4 *LB1- 630
 2100601 -90. 4 *LB1- 631
 2100801 3.81-6 0.172 4 *LB1- 632
 2100901 0.0 0.0 3 *LB1- 633
 2101001 00 04 *LB1- 634
 2101101 00000 03 *LB1- 635
 2101201 0 1.49069+7 1226629. 2461964. 0. 0. 1 *LB1- 636
 2101202 0 1.49120+7 1226639. 2461858. 0. 0. 2 *LB1- 637
 2101203 0 1.49216+7 1226648. 2461658. 0. 0. 3 *LB1- 638
 2101204 0 1.49296+7 1226655. 2461488. 0. 0. 4 *LB1- 639

2101300	0					*LB1- 640	
2101301	4.0043716	4.0043716	0.	1	* (M = 215.68 kg/s)	LB1- 641	
2101302	4.0043564	4.0043564	0.	2	* (M = 215.68 kg/s)	LB1- 642	
2101303	4.0043182	4.0043182	0.	3	* (M = 215.68 kg/s)	LB1- 643	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 644	
* junction - lower downcomer to lower plenum intact side						LB1- 645	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 646	
2150000	inanmuin	sngljun				*LB1- 647	
2150101	210010000	222000000	0.0709408	0.0000	0.0000	0100	*LB1- 648
2150201	0	3.1068134	3.1068134	0.	* (M = 215.68 kg/s)		LB1- 649
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 650	
* lower plenum top volume						LB1- 651	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 652	
2220000	"lwr plto"	branch				*LB1- 653	
2220001	2	0				*LB1- 654	
2220101	0.0	0.3533183	0.2592277	0.0	-90.	-0.3533183	*LB1- 655
2220102	3.81-6	0.0	00				*LB1- 656
2220200	0	1.49326+7	1226677.	2461426.	0.		*LB1- 657
2221101	222010000	220000000	0.0	0.005	0.005	0000	*LB1- 658
2222101	222000000	225000000	0.1499	1.5	1.5	0000	*LB1- 659
2221201	0.	0.	0.	* (M = -2.135-4 kg/s)			LB1- 660
2222201	2.6758347	2.6758347	0.	* (M = 304.54 kg/s)			LB1- 661
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 662	
* lower plenum bottom volume						LB1- 663	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 664	
2200000	"lwr plbo"	snglvlol				*LB1- 665	
2200101	0.0	0.3741720	0.29656	0.0	-90.	-0.3741720	*LB1- 666
2200102	4.0e-5	0.0	00				*LB1- 667
2200200	0	1.49353+7	1227759.	2461370.	0.		*LB1- 668
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 669	
* lower core support structure						LB1- 670	
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 671	
2250000	"1 corespp"	branch				*LB1- 672	
2250001	3	0				*LB1- 673	
2250101	0.2832456	0.5709989	0.0	0.0	90.	0.5709989	*LB1- 674
2250102	3.81-6	0.095	00				*LB1- 675
2250200	0	1.49243+7	1226681.	2461600.	0.		*LB1- 676
2251101	225010000	230000000	0.0	1.5	1.5	00100	*LB1- 677
2252101	225010000	231000000	0.0	1.5	1.5	00100	*LB1- 678
2253101	225010000	235000000	0.0	12.	12.	00100	*LB1- 679
2251201	2.1676121	2.6011333	0.	* (M = 242.76 kg/s)			LB1- 680
2252201	2.0351467	2.4421768	0.	* (M = 47.741 kg/s)			LB1- 681
2253201	0.8832984	0.8832984	0.	* (M = 14.036 kg/s)			LB1- 682

```

*---- -----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 683
* active core average channels (82 %) LB1- 684
*---- -----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 685
2300000 "core avg" pipe *LB1- 686
2300001 5 *LB1- 687
2300101 0.147510 1 *LB1- 688
2300102 0.137871 2 *LB1- 689
2300103 0.139239 3 *LB1- 690
2300104 0.138031 4 *LB1- 691
2300105 0.140191 5 *LB1- 692
2300201 0.142384 1 *LB1- 693
2300202 0.120254 2 *LB1- 694
2300203 0.142384 3 *LB1- 695
2300204 0.120254 4 *LB1- 696
2300301 0.432000 1 *LB1- 697
2300302 0.195000 3 *LB1- 698
2300303 0.280000 4 *LB1- 699
2300304 0.5744204 5 *LB1- 700
2300401 0.0 5 *LB1- 701
2300501 0.0 5 *LB1- 702
2300601 90.0 5 *LB1- 703
2300801 1.27-7 0.0124 5 *LB1- 704
2300901 0.0 0.0 1 *LB1- 705
2300902 0.66 0.66 2 *LB1- 706
2300903 0.0 0.0 4 *LB1- 707
2301001 100 5 *LB1- 708
2301101 0000 4 *LB1- 709
2301201 0 1.49160+7 1267540. 2461774. 0. 0. 1 *LB1- 710
2301202 0 1.49125+7 1290328. 2461848. 0. 0. 2 *LB1- 711
2301203 0 1.49087+7 1315376. 2461928. 0. 0. 3 *LB1- 712
2301204 0 1.49062+7 1347631. 2461972. 0. 0. 4 *LB1- 713
2301205 0 1.49019+7 1382139. 2462058. 0. 0. 5 *LB1- 714
2301300 0 *LB1- 715
2301301 2.2899361 2.7479229 0. 1 * (M = 242.76 kg/s) LB1- 716
2301302 2.742588 3.4933643 0. 2 * (M = 242.76 kg/s) LB1- 717
2301303 2.3472824 2.9397068 0. 3 * (M = 242.76 kg/s) LB1- 718
2301304 2.8279877 3.5388184 0. 4 * (M = 242.76 kg/s) LB1- 719
*---- -----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 720
* active core hot channels (14 %) LB1- 721
*---- -----1---- -----1---- -----1---- -----1---- -----1---- -----1---- LB1- 722
2310000 "core hot" pipe *LB1- 723
2310001 13 *LB1- 724
2310101 3.0897-2 1 *LB1- 725

```

2310102	2.98875-2	2						*LB1-	726
2310103	2.90272-2	8						*LB1-	727
2310104	2.89101-2	12						*LB1-	728
2310105	2.9881-2	13						*LB1-	729
2310201	3.1031-2	3						*LB1-	730
2310202	2.6208-2	4						*LB1-	731
2310203	3.1031-2	9						*LB1-	732
2310204	2.6208-2	10						*LB1-	733
2310205	3.1031-2	12						*LB1-	734
2310301	0.1397017	1						*LB1-	735
2310302	0.265	2						*LB1-	736
2310303	0.08833	8						*LB1-	737
2310304	0.1325	12						*LB1-	738
2310305	0.2117387	13						*LB1-	739
2310501	0.0	13						*LB1-	740
2310601	90.0	13						*LB1-	741
2310801	1.27-7	0.0124	13					*LB1-	742
2310901	0.0	0.0	3					*LB1-	743
2310902	0.66	0.66	4					*LB1-	744
2310903	0.0	0.0	9					*LB1-	745
2310904	0.66	0.66	10					*LB1-	746
2310905	0.0	0.0	12					*LB1-	747
2311001	100	13						*LB1-	748
2311101	0000	12						*LB1-	749
2311201	0	1.49181+7	1244536.	2461730.	0.	0.	1	*LB1-	750
2311202	0	1.49160+7	1282626.	2461776.	0.	0.	2	*LB1-	751
2311203	0	1.49141+7	1296847.	2461812.	0.00124	0.	3	*LB1-	752
2311204	0	1.49132+7	1311867.	2461832.	0.0023387	0.	4	*LB1-	753
2311205	0	1.49107+7	1327478.	2461880.	0.0039029	0.	5	*LB1-	754
2311206	0	1.49098+7	1343438.	2461900.	0.0068514	0.	6	*LB1-	755
2311207	0	1.49089+7	1359360.	2461916.	0.0109944	0.	7	*LB1-	756
2311208	0	1.49080+7	1374806.	2461932.	0.0157993	0.	8	*LB1-	757
2311209	0	1.49069+7	1395716.	2461950.	0.0231137	0.	9	*LB1-	758
2311210	0	1.49056+7	1413516.	2461968.	0.0283452	0.	10	*LB1-	759
2311211	0	1.49026+7	1427835.	2461998.	0.0316463	0.	11	*LB1-	760
2311212	0	1.49013+7	1439243.	2462028.	0.0309769	0.	12	*LB1-	761
2311213	0	1.48998+7	1452086.	2462070.	0.0254654	0.	13	*LB1-	762
2311300	0							*LB1-	763
2311301	2.0435925	2.571722	0.	1	*	(M = 47.741 kg/s)		LB1-	764
2311302	2.0827312	2.6167469	0.	2	*	(M = 47.741 kg/s)		LB1-	765
2311303	2.0993977	2.6302261	0.	3	*	(M = 47.741 kg/s)		LB1-	766
2311304	2.5073719	3.2380276	0.	4	*	(M = 47.741 kg/s)		LB1-	767
2311305	2.1380539	2.68367	0.	5	*	(M = 47.741 kg/s)		LB1-	768

2311306	2.1622353	2.7156086	0.	6	* (M = 47.741 kg/s)	LB1-	769		
2311307	2.1893768	2.7527866	0.	7	* (M = 47.741 kg/s)	LB1-	770		
2311308	2.2174587	2.7930908	0.	8	* (M = 47.741 kg/s)	LB1-	771		
2311309	2.2589722	2.8472137	0.	9	* (M = 47.741 kg/s)	LB1-	772		
2311310	2.7163639	3.4960823	0.	10	* (M = 47.741 kg/s)	LB1-	773		
2311311	2.3214836	2.9286175	0.	11	* (M = 47.741 kg/s)	LB1-	774		
2311312	2.3371143	3.021553	0.	12	* (M = 47.741 kg/s)	LB1-	775		
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----									
* core bypass volume (4 Prozent)									
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----									
2350000	"core byp"	pipe				*LB1-	779		
2350001	3					*LB1-	780		
2350101	2.0930-2	3				*LB1-	781		
2350201	0.0	2				*LB1-	782		
2350301	0.5588068	3				*LB1-	783		
2350401	0.0	3				*LB1-	784		
2350501	0.0	3				*LB1-	785		
2350601	90.0	3				*LB1-	786		
2350801	3.81-6	0.003	3			*LB1-	787		
2350901	0.0	0.0	2			*LB1-	788		
2351001	00	3				*LB1-	789		
2351101	0000	2				*LB1-	790		
2351201	0	1.49160+7	1226691.	2461774.	0.	0.	1 *LB1-	791	
2351202	0	1.49100+7	1226700.	2461900.	0.	0.	2 *LB1-	792	
2351203	0	1.49041+7	1226709.	2462024.	0.	0.	3 *LB1-	793	
2351300	0						*LB1-	794	
2351301	0.8833084	0.8833084	0.	1	* (M = 14.036 kg/s)	LB1-	795		
2351302	0.883316	0.883316	0.	2	* (M = 14.036 kg/s)	LB1-	796		
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----									
* upper end boxes and support structure									
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----									
2400000	"uprend b"	branch				*LB1-	800		
2400001	3	0				*LB1-	801		
2400101	0.2423341	0.5867979	0.0	0.0	90.	0.5867979	*LB1-	802	
2400102	3.81-6	0.145	00				*LB1-	803	
2400200	0	1.48946+7	1386723.	2462212.	0.		*LB1-	804	
2401101	230010000	240000000	0.0	1.5	1.5	00100	*LB1-	805	
2402101	231010000	240000000	0.0	1.5	1.5	00100	*LB1-	806	
2403101	235010000	240000000	0.0	12.	12.	00100	*LB1-	807	
2401201	2.4738331	3.0367889	0.	* (M = 242.76 kg/s)			LB1-	808	
2402201	2.4358578	3.3036118	0.	* (M = 47.741 kg/s)			LB1-	809	
2403201	0.8833241	0.9368153	0.	* (M = 14.036 kg/s)			LB1-	810	
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----									
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----									

* upper core support structure - cross flow region LB1- 812
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 813
2450000 "uprcores" branch *LB1- 814
2450001 2 0 *LB1- 815
2450101 0.0 0.4933248 0.1280806 0.0 90. 0.4933248 *LB1- 816
2450102 3.81-6 0.145 00 *LB1- 817
2450200 0 1.48910+7 1386845. 2462282. 0. *LB1- 818
2451101 240010000 245000000 0.0 0.0 0.0 0000 *LB1- 819
2452101 245010000 251000000 0.0 0.0 0.0 0000 *LB1- 820
2451201 1.8015003 1.8521795 0. * (M = 304.54 kg/s) LB1- 821
2452201 0. 0.0733461 0. * (M = -2.198-4 kg/s) LB1- 822
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 823
* upper flow skirt region LB1- 824
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 825
2500000 "uflw skr" branch *LB1- 826
2500001 1 0 *LB1- 827
2500101 0.1547532 0.7850547 0.0 0.0 90. 0.7850547 *LB1- 828
2500102 3.81-6 0.131 00 *LB1- 829
2500200 0 1.48847+7 1386868. 2462412. 0. *LB1- 830
2501101 245010000 250000000 0.0 0.0 0.0 0000 *LB1- 831
2501201 2.81954 2.9243202 0. * (M = 304.54 kg/s) LB1- 832
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 833
* dead end of fuel modules LB1- 834
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 835
2510000 "df1 mods" snglvlvol *LB1- 836
2510101 0.0 0.7844123 0.1154214 0.0 90. 0.7844123 *LB1- 837
2510102 3.81-6 0.214 00 *LB1- 838
2510200 0 1.48876+7 1388454. 2462370. 0. *LB1- 839
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 840
* upper head LB1- 841
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 842
2520000 "upr head" branch *LB1- 843
2520001 1 0 *LB1- 844
2520101 0.2622585 0.2869580 0.0 0.0 90. 0.2869580 *LB1- 845
2520102 3.81-6 0.0 00 *LB1- 846
2520200 0 1.48827+7 1386872. 2462472. 0. *LB1- 847
2521101 250010000 252000000 0.0 0.006 0.006 0000 *LB1- 848
2521201 2.8193226 2.8648758 0. * (M = 304.54 kg/s) LB1- 849
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 850
* upper plenum bottom volume LB1- 851
*----1----1----1----1----1----1----1----1----1----1----1---- LB1- 852
2550000 "uprpl bt" branch *LB1- 853
2550001 2 0 *LB1- 854

2550101	0.2622585	0.6312304	0.0	0.0	90.	0.6312304	*LB1-	855
2550102	3.81-6	0.0	00				*LB1-	856
2550200	0	1.48826+7	1387563.	2462476.	0.		*LB1-	857
2551101	250010000	255000000	0.0	0.006	0.006	0000	*LB1-	858
2552101	255010000	260000000	0.0	0.03	0.03	0000	*LB1-	859
2551201	0.	0.040443	0.	* (M =-3.725-4 kg/s)			LB1-	860
2552201	0.	0.	0.	* (M =-1.957-4 kg/s)			LB1-	861
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----
* upper plenum top volume								
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----
2600000	"uprpl tp"	snglvol					*LB1-	865
2600101	0.0	0.7747094	0.1914909	0.0	90.	0.7747094	*LB1-	866
2600102	3.81-6	0.0	00				*LB1-	867
2600200	0	1.48778+7	1391166.	2462576.	0.		*LB1-	868
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----
* inlet annulus upper volume broken side								
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----
2700000	"inanuprb"	annulus					*LB1-	872
2700001	1						*LB1-	873
2700101	0.1308530	1					*LB1-	874
2700301	0.1876129	1					*LB1-	875
2700401	0.0	1					*LB1-	876
2700501	0.0	1					*LB1-	877
2700601	90.0	1					*LB1-	878
2700801	3.81-6	0.172	1				*LB1-	879
2701001	00	1					*LB1-	880
2701201	0	1.48994+7	1226634.	2462122.	0.	0.	1	*LB1- 881
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----
* junction - middle to upper inlet annulus broken side								
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----
2710000	"inanmubk"	sngljun					*LB1-	885
2710101	272000000	270000000	0.129467	0.0000	0.0000	0100	*LB1-	886
2710201	0	-0.894464	-0.894464	0.	* (M =-88.864 kg/s)		LB1-	887
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----
* inlet annulus middle volume broken side								
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----
2720000	"inanmidb"	annulus					*LB1-	891
2720001	1						*LB1-	892
2720101	0.1308530	1					*LB1-	893
2720301	0.2851823	1					*LB1-	894
2720401	0.0	1					*LB1-	895
2720501	0.0	1					*LB1-	896
2720601	-90.0	1					*LB1-	897

2720801	3.81-6	0.172	1				*LB1- 898
2721001	00	1					*LB1- 899
2721201	0	1.49008+7	1226641.	2462092.	0.	0.	1 *LB1- 900
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1- 901
* junction - middle to lower inlet annulus broken side							LB1- 902
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1- 903
2750000	"inanmlbk"	sngljun					*LB1- 904
2750101	272010000	280000000	0.0709408	0.0	0.0	0100	*LB1- 905
2750201	0	0.8944659	0.8944659	0.	*	(M = 88.864 kg/s)	LB1- 906
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1- 907
* inlet annulus lower volume broken side							LB1- 908
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1- 909
2800000	"brok dow"	annulus					*LB1- 910
2800001	4						*LB1- 911
2800101	0.1464354	1					*LB1- 912
2800102	0.0	4					*LB1- 913
2800201	0.0709408	3					*LB1- 914
2800301	0.2525361	1					*LB1- 915
2800302	1.5200561	2					*LB1- 916
2800303	1.2616333	3					*LB1- 917
2800304	1.0792591	4					*LB1- 918
2800401	0.0	1					*LB1- 919
2800402	0.1581866	2					*LB1- 920
2800403	0.1217000	3					*LB1- 921
2800404	0.0986806	4					*LB1- 922
2800501	0.0	4					*LB1- 923
2800601	-90.	4					*LB1- 924
2800801	3.81-6	0.172	4				*LB1- 925
2800901	0.0	0.0	3				*LB1- 926
2801001	00	04					*LB1- 927
2801101	0000	03					*LB1- 928
2801201	0	1.49019+7	1226646.	2462070.	0.	0.	1 *LB1- 929
2801202	0	1.49082+7	1226669.	2461938.	0.	0.	2 *LB1- 930
2801203	0	1.49184+7	1226688.	2461722.	0.	0.	3 *LB1- 931
2801204	0	1.49270+7	1226703.	2461542.	0.	0.	4 *LB1- 932
2801300	0						*LB1- 933
2801301	1.6498756	1.6498756	0.	1	*	(M = 88.864 kg/s)	LB1- 934
2801302	1.6498709	1.6498709	0.	2	*	(M = 88.863 kg/s)	LB1- 935
2801303	1.6498575	1.6498575	0.	3	*	(M = 88.863 kg/s)	LB1- 936
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1- 937
2850000	"lrdc2lpb"	sngljun					*LB1- 938
2850101	280010000	222000000	0.0709408	0.0000	0.0000	0100	*LB1- 939
2850201	0	1.2800694	1.2800694	0.	*	(M = 88.862 kg/s)	LB1- 940

```

*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 941
29000000 lwrinann sngljun *LB1- 942
2900101 200000000 270000000 0.0296780 1.8341 1.8341 0003 *LB1- 943
2900201 0 3.943718 3.943718 0. * (M = 88.864 kg/s) LB1- 944
*
*
*$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$ LB1- 945
*LB1- 946
LB1- 946
LB1- 946
LB1- 947
LB1- 948
LB1- 948
LB1- 949
LB1- 949
LB1- 950
LB1- 951
LB1- 952
LB1- 953
LB1- 954
LB1- 955
LB1- 956
LB1- 957
LB1- 958
LB1- 959
LB1- 960
LB1- 961
LB1- 962
LB1- 963
LB1- 964
LB1- 965
LB1- 966
LB1- 967
LB1- 968
LB1- 969
LB1- 970
LB1- 971
LB1- 972
LB1- 973
LB1- 974
LB1- 975
LB1- 976
LB1- 977
LB1- 978
LB1- 979
LB1- 980
LB1- 981
LB1- 982
LB1- 983
* broken loop [ 300 ]
*
*$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$ LB1- 947
*LB1- 948
LB1- 948
LB1- 949
LB1- 950
LB1- 951
LB1- 952
* reactor vessel nozzle - broken loop hot leg
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 953
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 954
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 955
3000000 "rvn blhl" branch *LB1- 956
3000001 2 0 *LB1- 957
3000101 0.0 0.876303 0.0575410 0.0 0.0 0.0 *LB1- 958
3000102 4.0e-5 0.0 00 *LB1- 959
3000200 0 1.48827+7 1227851. 2462474. 0. *LB1- 960
3001101 252010000 300000000 0.067014 0.7385868 1.2309481 0002 *LB1- 961
3002101 300010000 305000000 0.063426 0.1005 0.1005 0000 *LB1- 962
3001201 0. 0. 0. * (M =-6.939-4 kg/s) LB1- 963
3002201 0. 0. 0. * (M =-6.533-4 kg/s) LB1- 964
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 965
* hot leg pipe to reflood assist bypass tee
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 966
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 967
3050000 "hlp-rabs" branch *LB1- 968
3050001 1 0 *LB1- 969
3050101 0.0 0.698336 0.0442927 0.0 0.0 0.0 *LB1- 970
3050102 4.0e-5 0.0 00 *LB1- 971
3050200 0 1.48827+7 1227509. 2462474. 0. *LB1- 972
3051101 305010000 310000000 0.063426 0.1005 0.1005 0000 *LB1- 973
3051201 0. 0. 0. * (M =-6.220-4 kg/s) LB1- 974
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 975
* broken loop hot leg contraction
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 976
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1- 977
3100000 "blhl ctr" branch *LB1- 978
3100001 2 0 *LB1- 979
3100101 0.0 1.50013 0.0678467 0.0 0.0 0.0 *LB1- 980
3100102 4.0e-5 0.0 00 *LB1- 981
3100200 0 1.48827+7 1227508. 2462474. 0. *LB1- 982
3101101 380010000 310000000 0.0388 0.84 0.84 0000 *LB1- 983

```

3102101	310010000	315000000	8.3647-3	0.553	1.09056	0000	*LB1- 984
3101201	0.	0.	0.	*	(M = 1.333-4 kg/s)		LB1- 985
3102201	0.	0.	0.	*	(M = -4.406-4 kg/s)		LB1- 986
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 987
* steam generator and pump simulation							LB1- 988
-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1- 989
3150000	"sg+pmp s"		pipe				*LB1- 990
3150001	8						*LB1- 991
3150101	0.0	8					*LB1- 992
3150201	8.3647-3	1					*LB1- 993
3150202	1.12-2	2					*LB1- 994
3150203	0.105626	3					*LB1- 995
3150204	1.12-2	4					*LB1- 996
3150205	8.3647-3	7					*LB1- 997
3150301	0.919969	1					*LB1- 998
3150302	1.987956	2					*LB1- 999
3150303	0.849744	4					*LB1-1000
3150304	1.987956	5					*LB1-1001
3150305	1.371350	6					*LB1-1002
3150306	1.365029	7					*LB1-1003
3150307	1.674812	8					*LB1-1004
3150401	7.75291-3	1					*LB1-1005
3150402	0.1721108	2					*LB1-1006
3150403	8.97552-2	4					*LB1-1007
3150404	0.1721108	5					*LB1-1008
3150405	1.82303-2	6					*LB1-1009
3150406	5.46687-2	7					*LB1-1010
3150407	1.82489-2	8					*LB1-1011
3150601	90.0	3					*LB1-1012
3150602	-90.0	7					*LB1-1013
3150603	90.0	8					*LB1-1014
3150701	0.679201	1					*LB1-1015
3150702	1.987956	2					*LB1-1016
3150703	0.457202	3					*LB1-1017
3150704	-0.457202	4					*LB1-1018
3150705	-1.987956	5					*LB1-1019
3150707	-1.371350	6					*LB1-1020
3150708	-0.520701	7					*LB1-1021
3150709	1.212851	8					*LB1-1022
3150801	4.0e-5	0.0	8				*LB1-1023
3150901	0.93596	0.93596	1				*LB1-1024
3150902	2.0	2.0	2				*LB1-1025
3150903	0.5	0.5	3				*LB1-1026

3150904	2.0	2.0	4					*LB1-1027
3150905	0.23025	0.23025	5					*LB1-1028
3150906	2.534	2.534	6					*LB1-1029
3150907	5.069	5.069	7					*LB1-1030
3151001	00	8						*LB1-1031
3151101	0000	7						*LB1-1032
3151201	0	1.48802+7	1227509.	2462526.	0.	0.	1	*LB1-1033
3151202	0	1.48703+7	1227509.	2462736.	0.	0.	2	*LB1-1034
3151203	0	1.48612+7	1227509.	2462928.	0.	0.	3	*LB1-1035
3151204	0	1.48612+7	1227510.	2462928.	0.	0.	4	*LB1-1036
3151205	0	1.48703+7	1227510.	2462736.	0.	0.	5	*LB1-1037
3151206	0	1.48828+7	1227510.	2462472.	0.	0.	6	*LB1-1038
3151207	0	1.48898+7	1227510.	2462324.	0.	0.	7	*LB1-1039
3151208	0	1.48872+7	1227510.	2462378.	0.	0.	8	*LB1-1040
3151300	0							*LB1-1041
3151301	0.	0.	0.	7	* (M = -4.351-4 kg/s)			LB1-1042
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----								LB1-1043
* hot leg break valve								LB1-1044
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----								LB1-1045
3170000	"hl break"	valve						*LB1-1046
3170101	315010000	700000000	8.3647-3	1.10813	1.06560	0100		*LB1-1047
3170102	0.93	0.84						*LB1-1048
3170201	0	0.	0.	0.	* (M = 0.0000 kg/s)			LB1-1049
3170300	trpvlv							*LB1-1050
3170301	510							*LB1-1051
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----								LB1-1052
* reactor vessel nozzle - broken loop cold leg								LB1-1053
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----								LB1-1054
3350000	"rvn blcl"	branch						*LB1-1055
3350001	2	0						*LB1-1056
3350101	0.0	0.749305	0.047979	0.0	0.0	0.0		*LB1-1057
3350102	4.0e-5	0.0	00					*LB1-1058
3350200	0	1.49008+7	1227507.	2462092.	0.			*LB1-1059
3351101	272000000	335000000	0.064130	1.455594	0.812933	0002		*LB1-1060
3352101	335010000	340000000	0.063426	0.1005	0.1005	0000		*LB1-1061
3351201	0.	0.	0.	* (M = -2.646-4 kg/s)				LB1-1062
3352201	0.	0.	0.	* (M = -2.307-4 kg/s)				LB1-1063
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----								LB1-1064
* cold leg pipe to reflood assist bypass tee								LB1-1065
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----								LB1-1066
3400000	"clp-rabs"	branch						*LB1-1067
3400001	1	0						*LB1-1068
3400101	0.0	0.698336	0.0443927	0.0	0.0	0.0		*LB1-1069

3400102	4.0e-5	0.0	00					*LB1-1070
3400200	0	1.49008e+7	1227506.	2462092.	0.			*LB1-1071
3401101	340010000	342000000	0.063426	0.1005	0.1005	0000		*LB1-1072
3401201	0.	0.	0.	*	(M = -1.993-4 kg/s)			LB1-1073
*----	-1-----	-1-----	-1-----	-1-----	-1-----	-1----		LB1-1074
* broken loop cold leg rabs to dtt								LB1-1075
*----	-1-----	-1-----	-1-----	-1-----	-1-----	-1----		LB1-1076
3420000	"blcl 2dt"		branch					*LB1-1077
3420001	1	0						*LB1-1078
3420101	0.0	0.5715069	0.0362484	0.0	0.0	0.0		*LB1-1079
3420102	4.0e-5	0.0	00					*LB1-1080
3420200	0	1.49008e+7	1227506.	2462092.	0.			*LB1-1081
3421101	342000000	370000000	0.0388	0.84	0.84	0000		*LB1-1082
3421201	0.	0.	0.	*	(M = -1.517-4 kg/s)			LB1-1083
*----	-1-----	-1-----	-1-----	-1-----	-1-----	-1----		LB1-1084
* broken loop cold leg dtt to break plane								LB1-1085
*----	-1-----	-1-----	-1-----	-1-----	-1-----	-1----		LB1-1086
3440000	"blcl 2br"		branch					*LB1-1087
3440001	1	0						*LB1-1088
3440101	0.0	0.9286231	0.0310679	0.0	0.0	0.0		*LB1-1089
3440102	4.0e-5	0.0	00					*LB1-1090
3440200	0	1.49008e+7	1227507.	2462092.	0.			*LB1-1091
3441101	342010000	344000000	0.0540157	6.545	14.05	0000		*LB1-1092
3441201	0.	0.	0.	*	(M = -2.198-5 kg/s)			LB1-1093
*----	-1-----	-1-----	-1-----	-1-----	-1-----	-1----		LB1-1094
* cold leg break valve								LB1-1095
*----	-1-----	-1-----	-1-----	-1-----	-1-----	-1----		LB1-1096
3470000	"cl break"		valve					*LB1-1097
3470101	344010000	705000000	8.3647e-3	0.81969	0.96836	0100		*LB1-1098
3470102	0.93	0.84						*LB1-1099
3470201	0	0.	0.	0.	*	(M = 0.0000 kg/s)		LB1-1100
3470300	trpvlv							*LB1-1101
3470301	510							*LB1-1102
*----	-1-----	-1-----	-1-----	-1-----	-1-----	-1----		LB1-1103
* reflood assist bypass piping - cold leg side								LB1-1104
*----	-1-----	-1-----	-1-----	-1-----	-1-----	-1----		LB1-1105
3700000	"rabs clg"		pipe					*LB1-1106
3700001	3							*LB1-1107
3700101	0.0388	2						*LB1-1108
3700102	0.0776	3						*LB1-1109
3700201	0.0388	2						*LB1-1110
3700301	0.0	3						*LB1-1111
3700401	0.0279	1						*LB1-1112

3700402	0.070	2		*LB1-1113	
3700403	0.1165	3		*LB1-1114	
3700601	90.0	1		*LB1-1115	
3700602	0.0	3		*LB1-1116	
3700701	0.64	1		*LB1-1117	
3700702	0.0	3		*LB1-1118	
3700801	4.0-5	0.0	3	*LB1-1119	
3700901	0.28	0.28	1	*LB1-1120	
3700902	0.84	0.84	2	*LB1-1121	
3701001	00	3		*LB1-1122	
3701101	0000	2		*LB1-1123	
3701201	0	1.48985+7	1227506.	2462142. 0. 0. 1 *LB1-1124	
3701202	0	1.48961+7	1227506.	2462192. 0. 0. 2 *LB1-1125	
3701203	0	1.48961+7	1227506.	2462192. 0. 0. 3 *LB1-1126	
3701300	0			*LB1-1127	
3701301	0.	0.	0.	2 * (M = -1.319-4 kg/s) LB1-1128	
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1129					
* reflood assist bypass valves LB1-1130					
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1131					
3750000	"rab vlv"	valve			*LB1-1132
3750101	370010000	3800000000	0.0	0.90+4 0.90+4 0000	*LB1-1133
3750201	0	0.	0.	* (M = 0.0000 kg/s)	LB1-1134
3750300	trpvlv				*LB1-1135
3750301	514				*LB1-1136
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1137					
* reflood assist bypass piping - hot leg side LB1-1138					
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1139					
3800000	"rabs h l"	pipe			*LB1-1140
3800001	3				*LB1-1141
3800101	0.0776	1			*LB1-1142
3800102	0.0388	3			*LB1-1143
3800201	0.0388	2			*LB1-1144
3800301	0.0	3			*LB1-1145
3800401	0.0915	1			*LB1-1146
3800402	0.048	2			*LB1-1147
3800403	0.0489	3			*LB1-1148
3800601	0.0	1			*LB1-1149
3800602	-90.0	2			*LB1-1150
3800603	0.0	3			*LB1-1151
3800701	0.0	1			*LB1-1152
3800702	-0.64	2			*LB1-1153
3800703	0.0	3			*LB1-1154
3800801	4.0-5	0.0	3		*LB1-1155

3800901	0.84	0.84	1		*LB1-1156				
3800902	0.28	0.28	2		*LB1-1157				
3801001	00	3			*LB1-1158				
3801101	0000	2			*LB1-1159				
3801201	0	1.48780+7	1227508.	2462574.	0.	0.	1	*LB1-1160	
3801202	0	1.48803+7	1227508.	2462524.	0.	0.	2	*LB1-1161	
3801203	0	1.48827+7	1227508.	2462474.	0.	0.	3	*LB1-1162	
3801300	0							*LB1-1163	
3801301	0.	0.	0.	2	* (M = 6.475-5 kg/s)			LB1-1164	
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1165
*									LB1-1166
*									LB1-1167
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*									LB1-1168
*									LB1-1169
* pressurizer [400]									LB1-1170
*									LB1-1171
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*									LB1-1172
*									LB1-1173
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1174
* surge line pcs side									LB1-1175
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1176
4000000	"srgli pc"		branch						*LB1-1177
4000001	2	0							*LB1-1178
4000101	1.44561-3	2.30	0.0	0.0	90.0	0.54			*LB1-1179
4000102	2.3622-5	0.0	00						*LB1-1180
4000200	0	1.48563+7	1476973.	2463030.	0.				*LB1-1181
4001101	107000000	400000000	1.44561-3	3.9	3.9	0002			*LB1-1182
4002101	400010000	405000000	1.44561-3	2.85	2.85	1000			*LB1-1183
4001201	-0.014768	-0.01474	0.	* (M = -0.0141 kg/s)					LB1-1184
4002201	-0.014763	-0.014763	0.	* (M = -0.0139 kg/s)					LB1-1185
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1186
* pressurizer surge line									LB1-1187
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1188
4050000	"srgli pz"		pipe						*LB1-1189
4050001	2								*LB1-1190
4050101	1.44561-3	2							*LB1-1191
4050201	1.44561-3	1							*LB1-1192
4050301	2.30	2							*LB1-1193
4050401	0.0	2							*LB1-1194
4050601	90.0	2							*LB1-1195
4050701	0.30	2							*LB1-1196
4050801	2.3622-5	0.0	2						*LB1-1197
4050901	2.85	2.85	1						*LB1-1198

4051001	00	2								*LB1-1199
4051101	1000	1								*LB1-1200
4051201	0	1.48536+7	1488259.	2463086.	0.	0.	1			*LB1-1201
4051202	0	1.48517+7	1490898.	2463126.	0.	0.	2			*LB1-1202
4051300	0									*LB1-1203
4051301	-0.014758	-0.014758	0.	1	* (M =-0.0139 kg/s)					LB1-1204
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1205
* pressurizer surge line										
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1206
4100000	"srg line"	sngljun								*LB1-1208
4100101	405010000	415000000	1.44561-3	0.42	1.00	1000				*LB1-1209
4100201	0	-0.014754	-0.014754	0.	* (M =-0.0139 kg/s)					LB1-1210
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1211
* pressurizer vessel										
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1212
4150000	"pvr vess"	pipe								*LB1-1214
4150001	6									*LB1-1215
4150101	0.0	2								*LB1-1216
4150102	0.5653	5								*LB1-1217
4150103	0.0	6								*LB1-1218
4150201	0.0	5								*LB1-1219
4150301	0.1815	1								*LB1-1220
4150302	0.1524	2								*LB1-1221
4150303	0.3967	3								*LB1-1222
4150304	0.5289	4								*LB1-1223
4150305	0.3967	5								*LB1-1224
4150306	0.1943	6								*LB1-1225
4150401	0.0684	1								*LB1-1226
4150402	0.0838	2								*LB1-1227
4150403	0.0	5								*LB1-1228
4150404	0.0732	6								*LB1-1229
4150501	0.0	6								*LB1-1230
4150601	90.0	6								*LB1-1231
4150801	4.0e-5	0.0	6							*LB1-1232
4151001	00	6								*LB1-1233
4151101	0000	5								*LB1-1234
4151201	0	1.48501+7	1492807.	2463160.	0.	0.	1			*LB1-1235
4151202	0	1.48491+7	1527267.	2463182.	0.	0.	2			*LB1-1236
4151203	0	1.48474+7	1554552.	2463216.	0.	0.	3			*LB1-1237
4151204	0	1.48452+7	1576769.	2468302.	0.4131663	0.	4			*LB1-1238
4151205	0	1.48440+7	1580450.	2463752.	1.	0.	5			*LB1-1239
4151206	0	1.48437+7	1580440.	2463292.	0.9999995	0.	6			*LB1-1240
4151300	0									*LB1-1241

4151301	0.	0.	0.	2	* (M = -0.0130 kg/s)	LB1-1242	
4151302	0.	0.8630719	0.	3	* (M = -0.0124 kg/s)	LB1-1243	
4151303	-0.667499	0.	0.	4	* (M = -0.0014 kg/s)	LB1-1244	
4151304	0.	0.	0.	5	* (M = -4.440-4 kg/s)	LB1-1245	
*						LB1-1246	
*****	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1247
* pressurizer vessel to top hat							LB1-1248
*****	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1249
4170000	"vssl-tph"		sngljun				*LB1-1250
4170101	415010000	420000000	0.0	0.0	0.0	0000	*LB1-1251
4170201	0	0.	0.	0.	* (M = -1.442-4 kg/s)	LB1-1252	
*****	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1253
* pressurizer top hat and relief connection							LB1-1254
*****	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1255
4200000	"pzz toph"		pipe				*LB1-1256
4200001	2						*LB1-1257
4200101	0.0	2					*LB1-1258
4200201	0.0	1					*LB1-1259
4200301	0.1104915	2					*LB1-1260
4200401	0.0139870	2					*LB1-1261
4200601	90.0	2					*LB1-1262
4200801	4.e-5	0.346066	2				*LB1-1263
4201001	00	2					*LB1-1264
4201101	0000	1					*LB1-1265
4201201	0	1.48436+7	1580434.	2483610.	1.	0.	1 *LB1-1266
4201202	0	1.48434+7	1580431.	2483894.	1.	0.	2 *LB1-1267
4201300	0						*LB1-1268
4201301	0.	0.	0.	1	* (M = -7.213-5 kg/s)	LB1-1269	
*****	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1270
*							LB1-1271
*							LB1-1272
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$							LB1-1273
*							LB1-1274
* steam generator secondary side [500]							LB1-1275
*							LB1-1276
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*							LB1-1277
*							LB1-1278
*****	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1279
* primary separator							LB1-1280
*****	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1281
5000000	"separat"		separatr				*LB1-1282
5000001	3	0					*LB1-1283
5000101	0.0	0.4445	0.2425	0.0	90.	0.4445	*LB1-1284

5000102	4.e-5	0.2840	00				*LB1-1285
5000200	0	5283040.	1165084.	2595300.	0.9202552		*LB1-1286
5001101	500010000	520000000	0.087745	0.0	0.0	0100	*LB1-1287
5002101	500000000	505000000	0.087745	0.0	0.0	0100	*LB1-1288
5003101	515010000	500000000	0.29187	0.4	0.4	0100	*LB1-1289
5001201	1.6183167	1.5961065	0.	* (M = 23.413 kg/s)			LB1-1290
5002201	0.3881891	0.3594913	0.	* (M = 89.399 kg/s)			LB1-1291
5003201	2.8275032	3.6115189	0.	* (M = 112.81 kg/s)			LB1-1292
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							
* separator bypass							
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							
5030000	"sepbypas"		branch				*LB1-1296
5030001	2	0					*LB1-1297
5030101	0.0	0.4445	0.4384	0.0	90.	0.4445	*LB1-1298
5030102	4.e-5	0.3678	00				*LB1-1299
5030200	0	5280204.	1161810.	2595276.	0.7249942		*LB1-1300
5031101	505000000	503000000	0.98627	0.0	0.0	0100	*LB1-1301
5032101	503010000	520000000	0.98627	0.8	0.0	0100	*LB1-1302
5031201	0.	0.4406047	0.	* (M = 2.4847 kg/s)			LB1-1303
5032201	-2.538778	0.1243373	0.	* (M = 2.3887 kg/s)			LB1-1304
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							
* separator outlet region							
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							
5050000	"lwr sepa"		branch				*LB1-1308
5050001	1	0					*LB1-1309
5050101	0.0	1.2131	1.4850	0.0	-90.	-1.2131	*LB1-1310
5050102	4.e-5	1.9048	00				*LB1-1311
5050200	0	5284396.	1165162.	2595304.	0.2041452		*LB1-1312
5051101	505010000	508000000	0.0	0.0	0.0	0100	*LB1-1313
5051201	0.3895128	0.0426888	0.	* (M = 86.880 kg/s)			LB1-1314
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							
* feed inlet volume							
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							
5080000	"upr dwnc"		branch				*LB1-1318
5080001	1	0					*LB1-1319
5080101	0.0	0.6096	0.22107	0.0	-90.	-0.6096	*LB1-1320
5080102	4.e-5	0.163697	00				*LB1-1321
5080200	0	5290364.	1098976.	2595264.	0.		*LB1-1322
5081101	508010000	510000000	0.0	0.0	0.0	0100	*LB1-1323
5081201	0.611732	0.4626126	0.	* (M = 112.65 kg/s)			LB1-1324
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							
* steam generator downcomer							
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							

5100000	"dwncmr"	annulus	*LB1-1328					
5100001	3		*LB1-1329					
5100101	0.232	3	*LB1-1330					
5100201	0.0	2	*LB1-1331					
5100301	0.6096	3	*LB1-1332					
5100401	0.0	3	*LB1-1333					
5100601	-90.0	3	*LB1-1334					
5100701	-0.6096	3	*LB1-1335					
5100801	4.e-5	0.10793	3	*LB1-1336				
5100901	0.0	0.0	2	*LB1-1337				
5101001	00	3	*LB1-1338					
5101101	0000	2	*LB1-1339					
5101201	0	5295012.	1099055.	2595228.	0.	0.	1	*LB1-1340
5101202	0	5299744.	1099085.	2595192.	0.	0.	2	*LB1-1341
5101203	0	5304476.	1099094.	2595158.	0.	0.	3	*LB1-1342
5101300	0							*LB1-1343
5101301	0.6112771	0.5503535	0.	1	* (M = 112.65 kg/s)			LB1-1344
5101302	0.6112561	0.5977697	0.	2	* (M = 112.65 kg/s)			LB1-1345
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1346
* junction - downcomer to boiler								LB1-1347
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1348
5130000	"dncmr-bl"	sngljun						*LB1-1349
5130101	510010000	515000000	0.0	17.5	17.5	0100		*LB1-1350
5130201	0	0.6112523	1.1637983	0.	* (M = 112.64 kg/s)			LB1-1351
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1352
* steam generator boiler								LB1-1353
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1354
5150000	"boiler"	pipe						*LB1-1355
5150001	5							*LB1-1356
5150101	0.2776	4						*LB1-1357
5150102	0.306294	5						*LB1-1358
5150201	0.0	4						*LB1-1359
5150301	1.8288	4						*LB1-1360
5150302	1.2131	5						*LB1-1361
5150401	0.0	5						*LB1-1362
5150601	60.0	4						*LB1-1363
5150602	90.0	5						*LB1-1364
5150701	0.6096	4						*LB1-1365
5150702	1.2131	5						*LB1-1366
5150801	4.e-5	0.0234	4					*LB1-1367
5150802	4.e-5	0.5962	5					*LB1-1368
5150901	4.05	4.05	4					*LB1-1369
5151001	100	5						*LB1-1370

5400201	0	16.441193	20.778671	0.00000	* (M = 25.803 kg/s)	LB1-1414	
5400300	mtrvlv					*LB1-1415	
5400301	687	688.000	0.20000	0.64829	540	*LB1-1416	
20254000	normarea					*LB1-1417	
20254001	0.0	0.0				*LB1-1418	
20254002	9.25-4	9.25-4				*LB1-1419	
20254003	1.0	1.0				*LB1-1420	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1421	
* pipe downstream of steam control valve						LB1-1422	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1423	
5410000	"cond inl"	branch				*LB1-1424	
5410001	1	0				*LB1-1425	
5410101	0.06557	54.44	0.0	0.0	0.0	*LB1-1426	
5410102	4.e-5	0.0	00			*LB1-1427	
5410200	0	2078494.	915144.5	2598364.	0.9981565	*LB1-1428	
5411101	541010000	542000000	0.0	0.0	0.0	0100	*LB1-1429
5411201	16.681183	35.27243	0.	* (M = 25.803 kg/s)		LB1-1430	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1431	
* air cooled condenser						LB1-1432	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1433	
5420000	"condens."	tmdpvol				*LB1-1434	
5420101	0.21677	17.67	0.0	0.0	0.0	*LB1-1435	
5420102	4.e-5	0.02	00			*LB1-1436	
5420200	2					*LB1-1437	
5420207	0.0	2.069e6	1.0			*LB1-1438	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1439	
* simplified feed system						LB1-1440	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1441	
* feed storage tank						LB1-1442	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1443	
5650000	"feettank"	tmdpvol				*LB1-1444	
5650101	29.81	3.048	0.0	0.0	0.0	*LB1-1445	
5650102	4.e-5	0.0	00			*LB1-1446	
5650200	3	0				*LB1-1447	
5650201	0.0	2.15323e6	477.6			*LB1-1448	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1449	
* feed water						LB1-1450	
-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1451	
5660000	"feed"	tmdpjun				*LB1-1452	
5660101	565000000	508000000	0.05			*LB1-1453	
5660200	1	511				*LB1-1454	
5660201	-100.0	25.770	0.0	0.0	*lp-lb-1	LB1-1455	
5660202	0.0	25.770	0.0	0.0	*lp-lb-1	LB1-1456	

5660203 0.5 15.95 0.0 0.0 *lp-lb-1 LB1-1457
 5660204 1.0 3.88 0.0 0.0 *lp-lb-1 LB1-1458
 5660205 1.5 1.39 0.0 0.0 *lp-lb-1 LB1-1459
 5660206 2.0 0.424 0.0 0.0 *lp-lb-1 LB1-1460
 5660207 2.5 0.105 0.0 0.0 *lp-lb-1 LB1-1461
 5660208 3.0 0.0 0.0 0.0 *lp-lb-1 LB1-1462
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1463
 * LB1-1464
 * LB1-1465
 \$\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$* LB1-1466
 * LB1-1467
 * ecc system [600] LB1-1468
 * LB1-1469
 \$\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$*\$\$* LB1-1470
 * LB1-1471
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1472
 * ecc check valve LB1-1473
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1474
 6000000 "ecc chkv" valve *LB1-1475
 6000101 605010000 185000000 5.9896-3 0.935 0.935 1120 *LB1-1476
 6000201 0 0. 0. 0. * (M = 0.0000 kg/s) LB1-1477
 6000300 trpvlv *LB1-1478
 6000301 681 *LB1-1479
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1480
 * eccs header to pcs LB1-1481
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1482
 6050000 "eccs hd" snglvol *LB1-1483
 6050101 5.9896-3 5.0148 0.0 0.0 90.0 3.3071202 *B1-1484
 6050102 4.0-5 0.0 00 *LB1-1485
 6050200 0 4500000. 172410. 2599486. 0. *LB1-1486
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1487
 * accumulator valve LB1-1488
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1489
 6100000 "accum v" valve *LB1-1490
 6100101 615010000 605000000 5.9896-3 6.278 6.278 1000 *LB1-1491
 6100201 0 0. 0. 0. * (M = 0.0000 kg/s) LB1-1492
 6100300 trpvlv *LB1-1493
 6100301 682 *LB1-1494
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1495
 * accumulator pipe LB1-1496
 *-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-1497
 6150000 "acc pipe" snglvol *LB1-1498
 6150101 0.0 25.997165 0.4074774 0.0 0.0 *LB1-1499

6150102	4.0-5	0.0	00				*LB1-1500
6150200	0	4236740.	112409.12	2600476.	0.		*LB1-1501
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1-1502
* accumulator vessel							LB1-1503
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1-1504
6200000	"accumul."		accum				*LB1-1505
6200101	1.2938	1.136	0.0	0.0	90.0	1.136	*LB1-1506
6200102	4.0-5	0.0	00				*LB1-1507
6200200	4.223+6	305.00	0.0				*LB1-1508
6201101	615000000	8.2132-3	125.	125.	00000		*LB1-1509
6202200	0.0	0.588	3.3266	0.8	0.04445	1	*LB1-1510
+	0.0	0.0					*LB1-1511
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1-1512
* bwst lpis							LB1-1513
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1-1514
6250000	"bwst lps"		tm dpvol				*LB1-1515
6250101	20.44	5.0	0.0	0.0	90.0	5.0	*LB1-1516
6250102	4.0e-5	0.0	00				*LB1-1517
6250200	3						*LB1-1518
6250201	0.0	1.0+5	300.0				*LB1-1519
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1-1520
* low pressure injection system							LB1-1521
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1-1522
6300000	"lpis"		tm dpjun				*LB1-1523
6300101	625000000	605000000	5.9896-3				*LB1-1524
6300200	1	513	p	605010000			*LB1-1525
6300201	-1.0	0.0	0.0	0.0			*LB1-1526
6300202	0.0	0.0	0.0	0.0			*LB1-1527
6300203	8.483+4	7.045	0.0	0.0			*LB1-1528
6300204	4.297+5	6.091	0.0	0.0			*LB1-1529
6300205	7.745+5	5.045	0.0	0.0			*LB1-1530
6300206	9.448+5	4.313	0.0	0.0			*LB1-1531
6300207	1.119+6	3.454	0.0	0.0			*LB1-1532
6300208	1.186+6	3.173	0.0	0.0			*LB1-1533
6300209	1.257+6	2.673	0.0	0.0			*LB1-1534
6300210	1.326+6	2.159	0.0	0.0			*LB1-1535
6300211	1.395+6	1.536	0.0	0.0			*LB1-1536
6300212	1.464+6	0.7182	0.0	0.0			*LB1-1537
6300213	1.517+6	0.0	0.0	0.0			*LB1-1538
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----							LB1-1539
*							LB1-1540
*							LB1-1541
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*							LB1-1542

* LB1-1543
 * containment [700] LB1-1544
 * LB1-1545
 * LB1-1546 LB1-1547
 * LB1-1548
 * containment broken loop hot leg LB1-1549
 * LB1-1550
 7000000 "cont tkh" tmdpvol *LB1-1551
 7000101 5.1956-2 0.0 104.68 0.0 0.0 0.0 *LB1-1552
 7000102 0.0 0.0 00 *LB1-1553
 7000200 2 511 *LB1-1554
 7000201 -1.0 115210. 1.0 * containment-pressure lbi LB1-1555
 7000202 0.0 115210. 1.0 *LB1-1556
 7000203 0.25 115555. 1.0 *LB1-1557
 7000204 0.5 173056. 1.0 *LB1-1558
 7000205 1.0 239590. 1.0 *LB1-1559
 7000206 2.0 207806. 1.0 *LB1-1560
 7000207 10. 270203. 1.0 *LB1-1561
 7000208 20. 330945. 1.0 *LB1-1562
 7000209 40. 282682. 1.0 *LB1-1563
 7000210 70. 335496. 1.0 *LB1-1564
 7000211 1.+5 100000. 1.0 *LB1-1565
 *-----1-----1-----1-----1-----1-----1-----1----- LB1-1566
 * containment broken loop cold leg LB1-1567
 *-----1-----1-----1-----1-----1-----1-----1----- LB1-1568
 7050000 "cont tkc" tmdpvol *LB1-1569
 7050101 2.35203-2 0.0 104.703 0.0 0.0 0.0 *LB1-1570
 7050102 0.0 0.0 00 *LB1-1571
 7050200 2 511 *LB1-1572
 7050201 -1.0 115210. 1.0 * containment-pressure lbi LB1-1573
 7050202 0.0 115210. 1.0 *LB1-1574
 7050203 0.25 115555. 1.0 *LB1-1575
 7050204 0.5 173056. 1.0 *LB1-1576
 7050205 1.0 239590. 1.0 *LB1-1577
 7050206 2.0 207806. 1.0 *LB1-1578
 7050207 10. 270203. 1.0 *LB1-1579
 7050208 20. 330945. 1.0 *LB1-1580
 7050209 40. 282682. 1.0 *LB1-1581
 7050210 70. 335496. 1.0 *LB1-1582
 7050211 1.+5 100000. 1.0 *LB1-1583
 *-----1-----1-----1-----1-----1-----1-----1----- LB1-1584
 *-----1-----1-----1-----1-----1-----1-----1----- LB1-1585

*										LB1-1586
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*										LB1-1587
*										LB1-1588
*										LB1-1589
heat structures										LB1-1590
*										LB1-1591
\$\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*\$*										LB1-1592
*										LB1-1593
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----										LB1-1594
* steam generator heat structures										LB1-1595
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----										*LB1-1596
11150000 8 8 2 0 0.0051054										*LB1-1597
11150100 0 1										*LB1-1598
11150101 7 0.006348984										*LB1-1599
11150201 6 7										*LB1-1600
11150301 0.0 7										*LB1-1601
11150400 -1										
11150401 565.91 563.13 560.36 557.59 554.82 552.04 549.27 546.50										*LB1-1602
11150402 562.78 560.50 558.22 555.94 553.66 551.38 549.10 546.82										*LB1-1603
11150403 560.84 559.04 557.25 555.46 553.67 551.88 550.09 548.29										*LB1-1604
11150404 558.74 557.14 555.53 553.92 552.32 550.71 549.11 547.50										*LB1-1605
11150405 556.93 555.50 554.07 552.64 551.21 549.78 548.35 546.92										*LB1-1606
11150406 554.98 553.76 552.54 551.32 550.10 548.89 547.67 546.45										*LB1-1607
11150407 552.60 551.47 550.35 549.22 548.09 546.96 545.83 544.70										*LB1-1608
11150408 550.79 549.80 548.81 547.83 546.84 545.85 544.86 543.87										*LB1-1609
11150501 115010000 10000 -1 1 1124.71 3										*LB1-1610
11150502 115040000 10000 1 1 849.063 5										*LB1-1611
11150503 115060000 10000 1 1 1124.71 8										*LB1-1612
11150601 515010000 10000 1 1 1124.71 3										*LB1-1613
11150602 515040000 0 1 1 849.063 4										*LB1-1614
11150603 515040000 0 1 1 849.063 5										*LB1-1615
11150604 515030000 -10000 1 1 1124.71 8										*LB1-1616
11150701 0 0 0 0 8										*LB1-1617
11150801 0 0 0 0 8										*LB1-1618
11150901 0 0 0 0 8										*LB1-1619
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----										LB1-1620
*										LB1-1621
* active core										LB1-1622
*										LB1-1623
* peripheral fuel modules										LB1-1624
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----										LB1-1625
12300000 5 10 2 0 0.0 2 1 32										*LB1-1626
12300001 7.869e+6 230050000										*LB1-1627
12300011 1.-6 2.-6 0.0 0.0 5										*LB1-1628

12300100	0	1						*LB1-1629	
12300101	5	4.647-3						*LB1-1630	
12300102	1	4.742-3						*LB1-1631	
12300103	3	5.359-3						*LB1-1632	
12300201	1	5						*LB1-1633	
12300202	-2	6						*LB1-1634	
12300203	-3	9						*LB1-1635	
12300301	1.0	5						*LB1-1636	
12300302	0.0	9						*LB1-1637	
12300400	-1							*LB1-1638	
12300401	1186.01	1161.45	1089.99	979.13	840.18	692.43	623.21	615.06	*LB1-1639
+ 607.14	599.46								*LB1-1640
12300402	1358.81	1327.45	1236.16	1094.56	917.07	728.34	639.93	629.51	*B1-1641
+ 619.40	609.58								*LB1-1642
12300403	1464.25	1428.75	1325.44	1165.17	964.28	750.67	650.61	638.82	*B1-1643
+ 627.38	616.27								*LB1-1644
12300404	1226.51	1200.83	1126.05	1010.07	864.68	710.09	637.68	629.15	*B1-1645
+ 620.86	612.82								*LB1-1646
12300405	789.09	781.04	757.62	721.30	675.76	627.34	604.66	601.99	*LB1-1647
+ 599.39	596.87								*LB1-1648
12300501	0	0	0	1	466.992	1			*LB1-1649
12300502	0	0	0	1	210.795	3			*LB1-1650
12300503	0	0	0	1	356.730	4			*LB1-1651
12300504	0	0	0	1	1064.091	5			*LB1-1652
12300601	230010000	0	1	1	466.991	1			*LB1-1653
12300602	230020000	10000	1	1	210.795	3			*LB1-1654
12300603	230040000	0	1	1	356.730	4			*LB1-1655
12300604	230050000	0	1	1	1064.091	5			*LB1-1656
12300701	900	.20308197	0.0	0.0	1				*LB1-1657
12300702	900	.11333616	0.0	0.0	2				*LB1-1658
12300703	900	.12500311	0.0	0.0	3				*LB1-1659
12300704	900	.16034587	0.0	0.0	4				*LB1-1660
12300705	900	.17183945	0.0	0.0	5				*LB1-1661
12300901	0	0.013633	0.0	0.0	5				*LB1-1662
-----1-----1-----1-----1-----1-----1-----1-----1-----								LB1-1663	
* center fuel module								LB1-1664	
-----1-----1-----1-----1-----1-----1-----1-----1-----								LB1-1665	
12310000	13	10	2	0	0.0	2	1	32	*LB1-1666
12310001	7.869e+6	231130000							*LB1-1667
12310011	1.0-6	2.0-6	0.0	0.0	13				*LB1-1668
12310100	0	1							*LB1-1669
12310101	5	4.647-3							*LB1-1670
12310102	1	4.742-3							*LB1-1671

12310103	3	5.359-3		*LB1-1672					
12310201	1	5		*LB1-1673					
12310202	-2	6		*LB1-1674					
12310203	-3	9		*LB1-1675					
12310301	1.00	5		*LB1-1676					
12310302	0.0	9		*LB1-1677					
12310400	-1			*LB1-1678					
12310401	1409.55	1374.54	1271.40	1108.34	908.92	707.74	638.30	628.13	*B1-1679
+	618.28	608.67							*LB1-1680
12310402	1558.69	1517.50	1396.19	1204.39	969.83	733.20	651.52	639.56	*B1-1681
+	627.97	616.67							*LB1-1682
12310403	1712.45	1664.60	1523.64	1300.79	1028.24	753.29	658.39	644.4	*B1-1683
+	631.03	617.90							*LB1-1684
12310404	1795.32	1743.88	1592.34	1352.76	1059.76	764.17	662.15	647.2	*B1-1685
+	632.73	618.61							*LB1-1686
12310405	1858.01	1803.85	1644.31	1392.07	1083.59	772.38	664.97	649.2	*B1-1687
+	634.00	619.13							*LB1-1688
12310406	1919.17	1862.36	1695.00	1430.41	1106.82	780.37	667.70	651.2	*B1-1689
+	635.21	619.62							*LB1-1690
12310407	1939.65	1881.95	1712.00	1443.30	1114.68	783.17	668.75	651.9	*B1-1691
+	635.75	619.92							*LB1-1692
12310408	1909.71	1853.32	1687.23	1424.65	1103.51	779.54	667.72	651.3	*B1-1693
+	635.48	620.00							*LB1-1694
12310409	1772.23	1721.85	1573.43	1338.79	1051.83	762.34	662.42	647.7	*B1-1695
+	633.61	619.78							*LB1-1696
12310410	1562.27	1521.04	1399.60	1207.59	972.77	735.88	654.12	642.14	*B1-1697
+	630.54	619.22							*LB1-1698
12310411	1317.46	1286.89	1196.85	1054.50	880.41	704.78	644.16	635.28	*B1-1699
+	626.68	618.29							*LB1-1700
12310412	1133.17	1110.62	1044.18	939.15	810.70	681.11	636.38	629.83	*LB1-1701
+	623.49	617.30							*LB1-1702
12310413	931.94	918.10	877.35	812.93	734.14	654.65	627.22	623.20	*LB1-1703
+	619.31	615.51							*LB1-1704
12310501	0	0	0	1	30.5947	1			*LB1-1705
12310502	0	0	0	1	58.035052	2			*LB1-1706
12310503	0	0	0	1	19.344287	8			*LB1-1707
12310504	0	0	0	1	29.017526	12			*LB1-1708
12310505	0	0	0	1	46.370817	13			*LB1-1709
12310601	231010000	0	1	1	30.5947	1			*LB1-1710
12310602	231020000	0	1	1	58.035052	2			*LB1-1711
12310603	231030000	10000	1	1	19.344287	8			*LB1-1712
12310604	231090000	10000	1	1	29.017526	12			*LB1-1713
12310605	231130000	0	1	1	46.370817	13			*LB1-1714

12310701	900	1.74501-2	0.0	0.0	1	*LB1-1715	
12310702	900	3.7340-2	0.0	0.0	2	*LB1-1716	
12310703	900	1.4071-2	0.0	0.0	3	*LB1-1717	
12310704	900	1.4937-2	0.0	0.0	4	*LB1-1718	
12310705	900	1.5587-2	0.0	0.0	5	*LB1-1719	
12310706	900	1.6235-2	0.0	0.0	6	*LB1-1720	
12310707	900	1.6452-2	0.0	0.0	7	*LB1-1721	
12310708	900	1.6127-2	0.0	0.0	8	*LB1-1722	
12310709	900	2.2017-2	0.0	0.0	9	*LB1-1723	
12310710	900	1.8672-2	0.0	0.0	10	*LB1-1724	
12310711	900	1.4612-2	0.0	0.0	11	*LB1-1725	
12310712	900	1.1203-2	0.0	0.0	12	*LB1-1726	
12310713	900	1.1675-2	0.0	0.0	13	*LB1-1727	
12310901	0	0.013633	0.0	0.0	13	*LB1-1728	
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1729	
*						LB1-1730	
* wall heat structures (core)						LB1-1731	
*						LB1-1732	
* volume 200						LB1-1733	
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1734	
12000000	1	5	2	0	0.508	*LB1-1735	
12000100	0	1				*LB1-1736	
12000101	4	0.7264				*LB1-1737	
12000201	4	4				*LB1-1738	
12000301	0.0	4				*LB1-1739	
12000400	-1					*LB1-1740	
12000401	555.79	555.82	555.86	555.89	555.92	*LB1-1741	
12000501	200010000	0	1	1	.093810	1	*LB1-1742
12000601	0	0	0	1	.09381	1	*LB1-1743
12000701	0	0.0	0.0	0.0	1	*LB1-1744	
12000801	0	0.1524	0.0	0.0	1	*LB1-1745	
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1746	
* volume 202						LB1-1747	
-----1-----1-----1-----1-----1-----1-----1-----1-----1-----						LB1-1748	
12020000	1	5	2	0	0.508	*LB1-1749	
12020100	0	1				*LB1-1750	
12020101	4	0.7264				*LB1-1751	
12020201	4	4				*LB1-1752	
12020301	0.0	4				*LB1-1753	
12020400	-1					*LB1-1754	
12020401	555.86	555.88	555.89	555.91	555.92	*LB1-1755	
12020501	202010000	0	1	1	.1426	1	*LB1-1756
12020601	0	0	0	1	.1426	1	*LB1-1757

12220100	0	1				*LB1-1801	
12220101	4	0.7264				*LB1-1802	
12220201	4	4				*LB1-1803	
12220301	0.0	4				*LB1-1804	
12220400	-1					*LB1-1805	
12220401	555.96	555.96	555.97	555.97	555.98	*LB1-1806	
12220501	222010000	0	1	1	0.36	1	*LB1-1807
12220601	0	0	0	1	0.36	1	*LB1-1808
12220701	0	0.0	0.0	0.0	1		*LB1-1809
12220801	0	0.1016	0.0	0.0	1		*LB1-1810
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1811
* core support structure (v225)							LB1-1812
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1813
12250000	1	5	2	0	0.282		*LB1-1814
12250100	0	1					*LB1-1815
12250101	4	0.3					*LB1-1816
12250201	4	4					*LB1-1817
12250301	0.0	4					*LB1-1818
12250400	-1						*LB1-1819
12250401	555.76	555.79	555.81	555.84	555.86		*LB1-1820
12250501	225010000	0	1	1	0.4269792	1	*LB1-1821
12250601	0	0	0	1	0.4269792	1	*LB1-1822
12250701	0	0.0	0.0	0.0	1		*LB1-1823
12250801	0	0.095	0.0	0.0	1		*LB1-1824
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1825
* volume 270							LB1-1826
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1827
12700000	1	5	2	0	0.508		*LB1-1828
12700100	0	1					*LB1-1829
12700101	4	0.7264					*LB1-1830
12700201	4	4					*LB1-1831
12700301	0.0	4					*LB1-1832
12700400	-1						*LB1-1833
12700401	555.79	555.82	555.85	555.88	555.92		*LB1-1834
12700501	270010000	0	1	1	0.09381	1	*LB1-1835
12700601	0	0	0	1	0.09381	1	*LB1-1836
12700701	0	0.0	0.0	0.0	1		*LB1-1837
12700801	0	0.1524	0.0	0.0	1		*LB1-1838
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1839
* volume 272							LB1-1840
*-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-1841
12720000	1	5	2	0	0.508		*LB1-1842
12720100	0	1					*LB1-1843



*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----	LB1-1887
* 900 reactor power vs time after scram	LB1-1888
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----	LB1-1889
20290000 power 511 1.0 49.3+6	*LB1-1890
20290001 -1.0 1.0 * lp-lb-1 (trac post-test)	LB1-1891
20290002 0.0 1.0	*LB1-1892
20290003 0.1 0.913489	*LB1-1893
20290004 0.2 0.278195	*LB1-1894
20290005 0.3 0.155347	*LB1-1895
20290006 0.4 0.112396	*LB1-1896
20290007 0.5 0.092927	*LB1-1897
20290008 0.6 0.084394	*LB1-1898
20290009 0.8 0.074600	*LB1-1899
20290010 1.0 0.066306	*LB1-1900
20290011 1.5 0.064594	*LB1-1901
20290012 2.0 0.061312	*LB1-1902
20290013 3.0 0.058698	*LB1-1903
20290014 4.0 0.056596	*LB1-1904
20290015 6.0 0.053434	*LB1-1905
20290016 8.0 0.051091	*LB1-1906
20290017 10.0 0.049237	*LB1-1907
20290018 60.0 0.032621	*LB1-1908
20290019 200. 0.024929	*LB1-1909
*	LB1-1910
*	LB1-1911
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----	LB1-1912
* heat structure thermal property data	LB1-1913
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----	LB1-1914
20100100 tbl/fctn 1 1 * uo2	LB1-1915
20100200 tbl/fctn 3 1 * gap	LB1-1916
20100300 tbl/fctn 1 1 * zr	LB1-1917
20100400 tbl/fctn 1 1 * s-steel	LB1-1918
20100500 c-steel	*LB1-1919
20100600 tbl/fctn 1 1 * inconel 600	LB1-1920
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----	LB1-1921
* uo2 - thermal conductivity	LB1-1922
*-----1-----1-----1-----1-----1-----1-----1-----1-----1-----1-----	LB1-1923
20100101 2.7315e2 8.44	*LB1-1924
20100102 4.1667e2 6.46	*LB1-1925
20100103 5.3315e2 5.782385	*LB1-1926
20100104 6.99817e2 4.633177	*LB1-1927
20100105 8.66483e2 3.880307	*LB1-1928
20100106 1.03315e3 3.357625	*LB1-1929



20100302	469.3	14.6	*LB1-1973
20100303	577.6	15.8	*LB1-1974
20100304	685.9	17.3	*LB1-1975
20100305	774.8	18.4	*LB1-1976
20100306	872.0	19.8	*LB1-1977
20100307	973.2	21.8	*LB1-1978
20100308	1073.2	23.2	*LB1-1979
20100309	1123.2	25.4	*LB1-1980
20100310	1152.3	24.2	*LB1-1981
20100311	1232.2	25.5	*LB1-1982
20100312	1331.2	26.6	*LB1-1983
20100313	1404.2	28.2	*LB1-1984
20100314	1576.2	33.0	*LB1-1985
20100315	1625.2	36.7	*LB1-1986
20100316	1755.2	41.2	*LB1-1987
20100317	2273.2	55.0	*LB1-1988
-----1-----1-----1-----1-----1-----1-----1-----1-----			
* zircaloy-4 - volumetric heat capacity from matpro			LB1-1989
-----1-----1-----1-----1-----1-----1-----1-----1-----			
20100351	300.0	1.841e6	LB1-1990
20100352	400.0	1.978e6	LB1-1991
20100353	640.0	2.168e6	LB1-1992
20100354	1090.0	2.456e6	LB1-1993
20100355	1093.0	3.288e6	LB1-1994
20100356	1113.0	3.865e6	LB1-1995
20100357	1133.0	4.028e6	LB1-1996
20100358	1153.0	4.709e6	LB1-1997
20100359	1173.0	5.345e6	LB1-1998
20100360	1193.0	5.044e6	LB1-1999
20100361	1213.0	4.054e6	LB1-2000
20100362	1233.0	3.072e6	LB1-2001
20100363	1243.0	2.332e6	LB1-2002
20100364	1477.0	2.332e6	LB1-2003
-----1-----1-----1-----1-----1-----1-----1-----1-----			
* s-steel - thermal conductivity			LB1-2004
-----1-----1-----1-----1-----1-----1-----1-----1-----			
20100401	273.15	12.98	LB1-2005
20100402	1199.82	25.1	LB1-2006
-----1-----1-----1-----1-----1-----1-----1-----1-----			
* s-steel - volumetric heat capacity			LB1-2007
-----1-----1-----1-----1-----1-----1-----1-----1-----			
20100451	273.15	3.83e6	LB1-2008
20100452	366.5	3.83e6	LB1-2009
-----1-----1-----1-----1-----1-----1-----1-----1-----			
*LB1-2010			LB1-2010
-----1-----1-----1-----1-----1-----1-----1-----1-----			
*LB1-2011			LB1-2011
-----1-----1-----1-----1-----1-----1-----1-----1-----			
*LB1-2012			LB1-2012
-----1-----1-----1-----1-----1-----1-----1-----1-----			
*LB1-2013			LB1-2013
-----1-----1-----1-----1-----1-----1-----1-----1-----			
*LB1-2014			LB1-2014
-----1-----1-----1-----1-----1-----1-----1-----1-----			
*LB1-2015			LB1-2015

20100453	477.59	4.190e6	*LB1-2016
20100454	588.59	4.336e6	*LB1-2017
20100455	699.82	4.504e6	*LB1-2018
20100456	810.93	4.639e6	*LB1-2019
20100457	922.04	4.773e6	*LB1-2020
20100458	1144.26	5.076e6	*LB1-2021
20100459	1366.5	5.376e6	*LB1-2022
20100460	1477.59	5.546e6	*LB1-2023
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2024			
* inconel-600 - thermal conductivity LB1-2025			
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2026			
20100601	366.5	13.85	*LB1-2027
20100602	477.6	15.92	*LB1-2028
20100603	588.7	18.17	*LB1-2029
20100604	700.0	20.42	*LB1-2030
20100605	810.9	22.50	*LB1-2031
20100606	922.0	24.92	*LB1-2032
20100607	1033.2	26.83	*LB1-2033
20100608	1144.3	29.42	*LB1-2034
20100609	1477.6	36.06	*LB1-2035
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2036			
* inconel-600 - volumetric heat capacity LB1-2037			
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2038			
20100651	366.5	3.908e6	*LB1-2039
20100652	477.6	4.084e6	*LB1-2040
20100653	588.7	4.260e6	*LB1-2041
20100654	700.0	4.436e6	*LB1-2042
20100656	810.9	4.665e6	*LB1-2043
20100657	922.0	4.929e6	*LB1-2044
20100658	1033.2	5.105e6	*LB1-2045
20100659	1477.6	5.727e6	*LB1-2046
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2047			
*			LB1-2048
*			LB1-2049
*			LB1-2050
\$\$\$\$\$\$\$\$\$\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$* LB1-2051			
*			LB1-2052
*	control variables		LB1-2053
*			LB1-2054
\$\$\$\$\$\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$* LB1-2055			
*			LB1-2056
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2057			
*	001-008 and 230-235 level calculators		LB1-2058

						LB1-2059
* 001 steam generator level						LB1-2060
						LB1-2061
20500100	sglvl	sum	1.	3.5255795	0	*LB1-2062
20500101	0.0	0.4445	voidf	503010000		*LB1-2063
20500102		1.2131	voidf	505010000		*LB1-2064
20500103		0.6096	voidf	508010000		*LB1-2065
20500104		0.6096	voidf	510010000		*LB1-2066
20500105		0.6096	voidf	510020000		*LB1-2067
20500106		0.6096	voidf	510030000		*LB1-2068
						LB1-2069
* 002 pressurizer level						LB1-2070
						LB1-2071
20500200	pzrlvl	sum	1.	1.0409756	0	*LB1-2072
20500201	0.0	0.1815	voidf	415010000		*LB1-2073
20500202		0.1524	voidf	415020000		*LB1-2074
20500203		0.3967	voidf	415030000		*LB1-2075
20500204		0.5289	voidf	415040000		*LB1-2076
20500205		0.3967	voidf	415050000		*LB1-2077
20500206		0.1943	voidf	415060000		*LB1-2078
20500207		0.1029	voidf	420010000		*LB1-2079
20500208		0.1029	voidf	420020000		*LB1-2080
						LB1-2081
* 004 accumulator level						LB1-2082
						LB1-2083
20500400	accmlvl	integral	-0.006348	0.5879979	0	*LB1-2084
20500401	velfj	620010000				*LB1-2085
						LB1-2086
* 007 reactor vessel downcomer level intact side						LB1-2087
						LB1-2088
20500700	rwdclvl	sum	1.	5.3137665	0	*LB1-2089
20500701	0.0	0.1876129	voidf	200010000		*LB1-2090
20500702		0.2851823	voidf	202010000		*LB1-2091
20500703		0.2525361	voidf	210010000		*LB1-2092
20500704		1.5200561	voidf	210020000		*LB1-2093
20500705		1.2616333	voidf	210030000		*LB1-2094
20500706		1.0792591	voidf	210040000		*LB1-2095
20500707		0.3533183	voidf	222010000		*LB1-2096
20500708		0.3741720	voidf	220010000		*LB1-2097
						LB1-2098
* 008 reactor vessel downcomer level broken side						LB1-2099
						LB1-2100
20500800	rwdclvl	sum	1.	5.3137665	0	*LB1-2101


```

*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2145
20524000 "void avg"           sum     2.9926155 1.0014334 0      *LB1-2146
20524001 0.0      .14751    cntrlvar  230                      *LB1-2147
20524002          3.0897-2  cntrlvar  231                      *LB1-2148
20524003          2.093-2   cntrlvar  235                      *LB1-2149
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2150
* 250 reactor vessel level                               LB1-2151
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2152
20525000 rvlvl             sum     1.       6.5347176 0      *LB1-2153
20525001 0.0      0.7747094 voidf    260010000                  *LB1-2154
20525002          0.6312304 voidf    255010000                  *LB1-2155
20525003          0.286958  voidf    252010000                  *LB1-2156
20525004          0.7850547 voidf    250010000                  *LB1-2157
20525005          0.4933248 voidf    245010000                  *LB1-2158
20525006          0.5867979 voidf    240010000                  *LB1-2159
20525007          0.74      cntrlvar  230                      *LB1-2160
20525008          0.155     cntrlvar  231                      *LB1-2161
20525009          0.105     cntrlvar  235                      *LB1-2162
20525010          0.5709989 voidf    225010000                  *LB1-2163
20525011          0.3533183 voidf    222010000                  *LB1-2164
20525012          0.3741720 voidf    220010000                  *LB1-2165
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2166
* 075-076 mass loss calculator                         LB1-2167
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2168
20507500 losssum            sum     1.       0.           0      *LB1-2169
20507501 0.0      1.0      mflowj   317000000                  *LB1-2170
20507502          1.0      mflowj   347000000                  *LB1-2171
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2172
20507600 lossmass           integral 1.       0.           0      *LB1-2173
20507601 cntrlvar  75
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2175
*
*
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2178
* 080-081 average values of pumps                   LB1-2179
*
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2180
* 080 average pump speed                          LB1-2181
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2182
20508000 pmpspeed            sum     1.       209.17993 0      *LB1-2183
20508001 0.0      0.5      pmpvel   135                      *LB1-2184
20508002          0.5      pmpvel   165                      *LB1-2185
*-----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2186
* 081 average pump head                           LB1-2187

```

```

***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2188
20508100 avgpmphd sum 1. 204090.5 0 *LB1-2189
20508101 0.0 0.5 pmphead 135 *LB1-2190
20508102 0.5 pmphead 165 *LB1-2191
***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2192
*
*
*
***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2195
* 090-098 power to fluid calculation LB1-2196
*
*
* 090 power average channel LB1-2198
***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2199
20509000 "power a" sum 1. 3.81403+7 0 *LB1-2200
20509001 0.0 1. q 230010000 *LB1-2201
20509002 1. q 230020000 *LB1-2202
20509003 1. q 230030000 *LB1-2203
20509004 1. q 230040000 *LB1-2204
20509005 1. q 230050000 *LB1-2205
***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2206
* 091 power hot channel LB1-2207
***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2208
20509100 "power h" sum 1. 1.11608+7 0 *LB1-2209
20509101 0.0 1. q 231010000 *LB1-2210
20509102 1. q 231020000 *LB1-2211
20509103 1. q 231030000 *LB1-2212
20509104 1. q 231040000 *LB1-2213
20509105 1. q 231050000 *LB1-2214
20509106 1. q 231060000 *LB1-2215
20509107 1. q 231070000 *LB1-2216
20509108 1. q 231080000 *LB1-2217
20509109 1. q 231090000 *LB1-2218
20509110 1. q 231100000 *LB1-2219
20509111 1. q 231110000 *LB1-2220
20509112 1. q 231120000 *LB1-2221
20509113 1. q 231130000 *LB1-2222
***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2223
* 092 total power LB1-2224
***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2225
20509200 power sum 1. 4.93011+7 0 *LB1-2226
20509201 0.0 1. cntrlvar 90 *LB1-2227
20509202 1. cntrlvar 91 *LB1-2228
***** -----1-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2229
* 093 heat sink (steam generator) LB1-2230

```

					LB1-2231
20509300	"heatsink"	sum	-1.	4.93949+7 0	*LB1-2232
20509301	0.0	1.	q	115010000	*LB1-2233
20509302		1.	q	115020000	*LB1-2234
20509303		1.	q	115030000	*LB1-2235
20509304		1.	q	115040000	*LB1-2236
20509305		1.	q	115050000	*LB1-2237
20509306		1.	q	115060000	*LB1-2238
20509307		1.	q	115070000	*LB1-2239
20509308		1.	q	115080000	*LB1-2240
					LB1-2241
*					LB1-2242
*					LB1-2243
* 095 - 098 power of structure heat capacity					LB1-2244
*					LB1-2245
* 095 structures downcomer intact loop					LB1-2246
					LB1-2247
20509500	"hc intl"	sum	1.	1941.8926 0	*LB1-2248
20509501	0.0	1.0	q	200010000	*LB1-2249
20509502		1.0	q	202010000	*LB1-2250
20509503		1.0	q	210010000	*LB1-2251
20509504		1.0	q	210020000	*LB1-2252
20509505		1.0	q	210030000	*LB1-2253
20509506		1.0	q	210040000	*LB1-2254
					LB1-2255
* 096 structures downcomer broken loop					LB1-2256
					LB1-2257
20509600	"hc brkl"	sum	1.	2181.7812 0	*LB1-2258
20509601	0.0	1.0	q	270010000	*LB1-2259
20509602		1.0	q	272010000	*LB1-2260
20509603		1.0	q	280010000	*LB1-2261
20509604		1.0	q	280020000	*LB1-2262
20509605		1.0	q	280030000	*LB1-2263
20509606		1.0	q	280040000	*LB1-2264
					LB1-2265
* 097 structures core barrel					LB1-2266
					LB1-2267
20509700	"hc core"	sum	1.	259.08643 0	*LB1-2268
20509701	0.0	1.0	q	220010000	*LB1-2269
20509702		1.0	q	222010000	*LB1-2270
20509703		1.0	q	225010000	*LB1-2271
					LB1-2272
*					LB1-2273

* 098 structures total		LB1-2274	
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2275	
20509800 heatcap	sum 1.	4382.7578 0	*LB1-2276
20509801 0.0 1.0	cntrlvar 95		*LB1-2277
20509802 1.0	cntrlvar 96		*LB1-2278
20509803 1.0	cntrlvar 97		*LB1-2279
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2280	
*		LB1-2281	
*		LB1-2282	
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2283	
* 510 - 520 trip-sets		LB1-2284	
*		LB1-2285	
* 510 blow-down valves		LB1-2286	
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2287	
20551000 blowdown	tripunit 1.	0. 0	*LB1-2288
20551001 510			*LB1-2289
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2290	
* 511 power scram		LB1-2291	
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2292	
20551100 powerscr	tripunit 1.	0. 0	*LB1-2293
20551101 511			*LB1-2294
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2295	
* 512 pump trip		LB1-2296	
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2297	
20551200 pumptrip	tripunit 1.	0. 0	*LB1-2298
20551201 512			*LB1-2299
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2300	
* 523 lpis trip		LB1-2301	
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2302	
20552300 lpistrip	tripunit 1.	0. 0	*LB1-2303
20552301 513			*LB1-2304
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2305	
* 524 accumulator valve		LB1-2306	
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2307	
20552400 accumulv	tripunit 1.	0. 0	*LB1-2308
20552401 682			*LB1-2309
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2310	
* 514 eccs		LB1-2311	
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2312	
20551400 eccs	sum 1.	0. 0	*LB1-2313
20551401 0.0 .3	cntrlvar 523		*LB1-2314
20551402 .7	cntrlvar 524		*LB1-2315
-----1---- -----1---- -----1---- -----1---- -----1---- -----1----		LB1-2316	

```

* 516 steam valve LB1-2317
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2318
20552600 steamvop tripunit 1. 0. 0 *LB1-2319
20552601 685 *LB1-2320
20552700 steamvcl tripunit -1. 0. 0 *LB1-2321
20552701 686 *LB1-2322
20551600 steamvlv sum 1. 0. 0 *LB1-2323
20551601 0.0 1.0 cntrlvar 526 *LB1-2324
20551602 1.0 cntrlvar 527 *LB1-2325
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2326
*
*
*
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2327
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2328
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2329
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2330
* 400-454 calculation of fluid-momentum flux LB1-2331
*
* 404 momentum flux of junction 34001 LB1-2332
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2333
20540000 "vf 340" stdfnctn 1. 4.13990-6 0 *LB1-2334
20540001 abs velfj 340010000 *LB1-2335
20540100 "vg 340" stdfnctn 1. 4.13990-6 0 *LB1-2336
20540101 abs velgj 340010000 *LB1-2337
*
20540200 "mfx1 340" mult 1. -1.3007-8 0 *LB1-2338
20540201 voidfj 340010000 rhoj 340010000 *LB1-2339
20540202 velfj 340010000 cntrlvar 400 *LB1-2340
20540300 "mfx2 340" mult 1. 0. 0 *LB1-2341
20540301 voidgj 340010000 rhogj 340010000 *LB1-2342
20540302 velgj 340010000 cntrlvar 401 *LB1-2343
*
20540400 "mf 340" sum 1. -1.3007-8 0 *LB1-2344
20540401 0.0 1.0 cntrlvar 402 *LB1-2345
20540402 1.0 cntrlvar 403 *LB1-2346
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2347
*
* 414 momentum flux of junction 31001 LB1-2348
*-----1---- -----1---- -----1---- -----1---- -----1---- LB1-2349
20541000 "vf 310" stdfnctn 1. 4.52749-6 0 *LB1-2350
20541001 abs velfj 310010000 *LB1-2351
20541100 "vg 310" stdfnctn 1. 4.52749-6 0 *LB1-2352
20541101 abs velgj 310010000 *LB1-2353
*
20541200 "mfx1 310" mult 1. 1.55564-8 0 *LB1-2354

```

20541201	voidfj	310010000	rhofj	310010000		*LB1-2360	
20541202	velfj	310010000	cntrlvar	410		*LB1-2361	
20541300	"mfx2 310"		mult	1.	0.	0	*LB1-2362
20541301	voidgj	310010000	rhogj	310010000			*LB1-2363
20541302	velgj	310010000	cntrlvar	411			*LB1-2364
*							LB1-2365
20541400	"mf 310"		sum	1.	1.55564-8	0	*LB1-2366
20541401		0.0		1.0			*LB1-2367
20541402				1.0			*LB1-2368
*-----1-----1-----1-----1-----1-----1-----1-----							LB1-2369
*							LB1-2370
* 424 momentum flux of junction 18502							LB1-2371
*-----1-----1-----1-----1-----1-----1-----1-----							LB1-2372
20542000	"vf 185"		stdfnctn	1.	6.3238869	0	*LB1-2373
20542001		abs	velfj	185020000			*LB1-2374
20542100	"vg 185"		stdfnctn	1.	6.3238869	0	*LB1-2375
20542101		abs	velgj	185020000			*LB1-2376
*							LB1-2377
20542200	"mfx1 185"		mult	1.	30364.766	0	*LB1-2378
20542201	voidfj	185020000	rhofj	185020000			*LB1-2379
20542202	velfj	185020000	cntrlvar	420			*LB1-2380
20542300	"mfx2 185"		mult	1.	0.	0	*LB1-2381
20542301	voidgj	185020000	rhogj	185020000			*LB1-2382
20542302	velgj	185020000	cntrlvar	421			*LB1-2383
*							LB1-2384
20542400	"mf 185"		sum	1.	30364.766	0	*LB1-2385
20542401		0.0		1.0			*LB1-2386
20542402				1.0			*LB1-2387
*-----1-----1-----1-----1-----1-----1-----1-----							LB1-2388
*							LB1-2389
* 434 momentum flux of junction 10002							LB1-2390
*-----1-----1-----1-----1-----1-----1-----1-----							LB1-2391
20543000	"vf 100"		stdfnctn	1.	6.8770447	0	*LB1-2392
20543001		abs	velfj	100020000			*LB1-2393
20543100	"vg 100"		stdfnctn	1.	6.8802338	0	*LB1-2394
20543101		abs	velgj	100020000			*LB1-2395
*							LB1-2396
20543200	"mfx1 100"		mult	1.	33010.531	0	*LB1-2397
20543201	voidfj	100020000	rhofj	100020000			*LB1-2398
20543202	velfj	100020000	cntrlvar	430			*LB1-2399
20543300	"mfx2 100"		mult	1.	0.0027149	0	*LB1-2400
20543301	voidgj	100020000	rhogj	100020000			*LB1-2401
20543302	velgj	100020000	cntrlvar	431			*LB1-2402

```

*
20543400 "mf 100"           sum     1.      33010.531 0      LB1-2403
20543401                 0.0    1.0    cntrlvar 432      *LB1-2404
20543402                 1.0    1.0    cntrlvar 433      *LB1-2405
*----1----1----1----1----1----1----1----1----1----1---- LB1-2406
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2407
*
* 444 momentum flux of junction 22502                   LB1-2408
*----1----1----1----1----1----1----1----1----1----1---- LB1-2409
20544000 "vf 225"          stdfnctn 1.      2.0351467 0      LB1-2410
20544001   abs    velfj    225020000      *LB1-2411
20544100 "vg 225"          stdfnctn 1.      2.4421768 0      LB1-2412
20544101   abs    velgj    225020000      *LB1-2413
20544102   abs    voidgj   225020000      *LB1-2414
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2415
20544200 "mfx1 225"        mult     1.      3144.6543 0      LB1-2416
20544201 voidfj   225020000 rhofj    225020000      *LB1-2417
20544202 velfj    225020000 cntrlvar 440      *LB1-2418
20544300 "mfx2 225"        mult     1.      0.      0.      LB1-2419
20544301 voidgj   225020000 rhogj    225020000      *LB1-2420
20544302 velgj    225020000 cntrlvar 441      *LB1-2421
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2422
20544400 "mf 225"          sum     1.      3144.6543 0      LB1-2423
20544401   0.0    1.0    cntrlvar 442      *LB1-2424
20544402   1.0    1.0    cntrlvar 443      *LB1-2425
*----1----1----1----1----1----1----1----1----1----1---- LB1-2426
*
* 454 momentum flux of junction 24002                   LB1-2427
*----1----1----1----1----1----1----1----1----1----1---- LB1-2428
20545000 "vf 240"          stdfnctn 1.      2.4358578 0      LB1-2429
20545001   abs    velfj    240020000      *LB1-2430
20545100 "vg 240"          stdfnctn 1.      3.3036118 0      LB1-2431
20545101   abs    velgj    240020000      *LB1-2432
20545102   abs    voidgj   240020000      *LB1-2433
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2434
20545200 "mfx1 240"        mult     1.      3872.1816 0      LB1-2435
20545201 voidfj   240020000 rhofj    240020000      *LB1-2436
20545202 velfj    240020000 cntrlvar 450      *LB1-2437
20545300 "mfx2 240"        mult     1.      26.596664 0      LB1-2438
20545301 voidgj   240020000 rhogj    240020000      *LB1-2439
20545302 velgj    240020000 cntrlvar 451      *LB1-2440
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2441
20545400 "mf 240"          sum     1.      3898.7773 0      LB1-2442
20545401   0.0    1.0    cntrlvar 452      *LB1-2443
20545402   1.0    1.0    cntrlvar 453      *LB1-2444
*----1----1----1----1----1----1----1----1----1----1---- LB1-2445

```

* LB1-2446
 * 460 - 464 pressure differences LB1-2447
 * LB1-2448
 *-----1-----1-----1-----1-----1-----1-----1----- LB1-2449
 * LB1-2450
 20546000 "pde001" sum 1. 181976.5 0 *LB1-2451
 20546001 0.0 -1.0 P 120010000 *LB1-2452
 20546002 1.0 P 150010000 *LB1-2453
 * LB1-2454
 20546100 "pde002" sum 1. -92313.69 0 *LB1-2455
 20546101 0.0 -1.0 P 112020000 *LB1-2456
 20546102 1.0 P 120010000 *LB1-2457
 * LB1-2458
 20546200 "pde003" sum 1. -11923.42 0 *LB1-2459
 20546201 0.0 -1.0 P 100010000 *LB1-2460
 20546202 1.0 P 112020000 *LB1-2461
 * LB1-2462
 20546300 "pde005" sum 1. -1468.106 0 *LB1-2463
 20546301 0.0 -1.0 P 150010000 *LB1-2464
 20546302 1.0 P 180010000 *LB1-2465
 * LB1-2466
 20546400 "pde006" sum 1. -76271.25 0 *LB1-2467
 20546401 0.0 -1.0 P 180010000 *LB1-2468
 20546402 1.0 P 100010000 *LB1-2469
 * LB1-2470
 *-----1-----1-----1-----1-----1-----1-----1----- LB1-2471
 * LB1-2472
 * 470 reactor-power LB1-2473
 * LB1-2474
 *-----1-----1-----1-----1-----1-----1-----1----- LB1-2475
 * LB1-2476
 20547000 "reac pow" function 1. 4.93000+7 0 *LB1-2477
 20547001 time 0 900 *LB1-2478
 * LB1-2479
 * LB1-2480
 \$\$\$\$\$\$\$\$\$\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$* * LB1-2481
 * LB1-2482
 * pump data LB1-2483
 * LB1-2484
 \$\$\$\$\$\$\$\$\$\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$*\$\$\$\$\$* * LB1-2485
 * LB1-2486
 *"""""" pump 1 LB1-2487
 * LB1-2488

*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2489
* single phase head curves								LB1-2490
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2491
* head curve no. 1								LB1-2492
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2493
1351100	1		1					*LB1-2494
1351101	0.000000e+00		1.403600e+00					*LB1-2495
1351102	1.906100e-01		1.363600e+00					*LB1-2496
1351103	3.896300e-01		1.318600e+00					*LB1-2497
1351104	5.939600e-01		1.232800e+00					*LB1-2498
1351105	7.902000e-01		1.133600e+00					*LB1-2499
1351106	1.000000e+00		1.000000e+00					*LB1-2500
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2501
* head curve no. 2								LB1-2502
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2503
1351200	1		2					*LB1-2504
1351201	0.000000e+00		-6.700000e-01					*LB1-2505
1351202	2.000000e-01		-5.000000e-01					*LB1-2506
1351203	4.000000e-01		-2.500000e-01					*LB1-2507
1351204	5.755400e-01		0.000000e+00					*LB1-2508
1351205	7.443200e-01		2.583000e-01					*LB1-2509
1351206	7.734800e-01		3.778000e-01					*LB1-2510
1351207	8.631300e-01		6.326000e-01					*LB1-2511
1351208	1.000000e+00		1.000000e+00					*LB1-2512
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2513
* head curve no. 3								LB1-2514
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2515
1351300	1		3					*LB1-2516
1351301	-1.000000e+00		2.472200e+00					*LB1-2517
1351302	-8.057400e-01		2.047400e+00					*LB1-2518
1351303	-6.069000e-01		1.831000e+00					*LB1-2519
1351304	-4.068300e-01		1.624000e+00					*LB1-2520
1351305	-2.001710e-01		1.470500e+00					*LB1-2521
1351306	0.000000e+00		1.403600e+00					*LB1-2522
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2523
* head curve no. 4								LB1-2524
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2525
1351400	1		4					*LB1-2526
1351401	-1.000000e+00		2.472200e+00					*LB1-2527
1351402	-8.229700e-01		1.996800e+00					*LB1-2528
1351403	-6.333200e-01		1.589700e+00					*LB1-2529
1351404	-4.553400e-01		1.327900e+00					*LB1-2530
1351405	-2.710900e-01		1.194900e+00					*LB1-2531

1351406	-1.771600e-01	1.060500e+00	*LB1-2532
1351407	-9.073000e-02	1.015600e+00	*LB1-2533
1351408	0.000000e+00	9.342790e-01	*LB1-2534
*----	-----1-----	-----1-----	-----1-----
* head curve no. 5			LB1-2535
*----	-----1-----	-----1-----	-----1-----
1351500	1	5	LB1-2536
1351501	0.000000e+00	2.500000e-01	*LB1-2537
1351502	2.000000e-01	2.800000e-01	*LB1-2538
1351503	4.000000e-01	3.400000e-01	*LB1-2539
1351504	4.118000e-01	2.768000e-01	*LB1-2540
1351505	5.976300e-01	4.584000e-01	*LB1-2541
1351506	7.934670e-01	6.992000e-01	*LB1-2542
1351507	1.000000e+00	1.000000e+00	*LB1-2543
*----	-----1-----	-----1-----	-----1-----
* head curve no. 6			LB1-2544
*----	-----1-----	-----1-----	-----1-----
1351600	1	6	LB1-2545
1351601	0.000000e+00	9.342790e-01	*LB1-2546
1351602	9.109900e-02	9.229000e-01	*LB1-2547
1351603	1.865090e-01	8.963000e-01	*LB1-2548
1351604	2.717620e-01	8.750000e-01	*LB1-2549
1351605	4.558720e-01	8.433000e-01	*LB1-2550
1351606	5.744060e-01	8.355000e-01	*LB1-2551
1351607	7.405760e-01	8.466000e-01	*LB1-2552
1351608	7.666190e-01	8.469000e-01	*LB1-2553
1351609	8.714710e-01	8.838000e-01	*LB1-2554
1351610	1.000000e+00	1.000000e+00	*LB1-2555
*----	-----1-----	-----1-----	-----1-----
* head curve no. 7			LB1-2556
*----	-----1-----	-----1-----	-----1-----
1351700	1	7	LB1-2557
1351701	-1.000000e+00	-1.000000e+00	*LB1-2558
1351702	-8.000000e-01	-6.300000e-01	*LB1-2559
1351703	-6.000000e-01	-3.000000e-01	*LB1-2560
1351704	-4.000000e-01	-5.000000e-02	*LB1-2561
1351705	-2.000000e-01	1.500000e-01	*LB1-2562
1351706	0.000000e+00	2.500000e-01	*LB1-2563
*----	-----1-----	-----1-----	-----1-----
* head curve no. 8			LB1-2564
*----	-----1-----	-----1-----	-----1-----
1351800	1	8	LB1-2565
1351801	-1.000000e+00	-1.000000e+00	*LB1-2566

1351802	-8.000000e-01	-9.700000e-01	*LB1-2575
1351803	-6.000000e-01	-9.500000e-01	*LB1-2576
1351804	-4.000000e-01	-8.800000e-01	*LB1-2577
1351805	-2.000000e-01	-8.000000e-01	*LB1-2578
1351806	0.000000e+00	-6.700000e-01	*LB1-2579
*	-----1-----	-----1-----	-----1-----
* single phase torque data			LB1-2580
*	-----1-----	-----1-----	-----1-----
* torque curve no. 1			LB1-2581
*	-----1-----	-----1-----	-----1-----
1351900	2	1	*LB1-2582
1351901	0.000000e+00	6.032000e-01	*LB1-2583
1351902	1.930000e-01	6.325000e-01	*LB1-2587
1351903	3.930000e-01	7.369000e-01	*LB1-2588
1351904	5.955200e-01	8.331000e-01	*LB1-2589
1351905	7.978200e-01	9.229000e-01	*LB1-2590
1351906	1.000000e+00	1.000000e+00	*LB1-2591
*	-----1-----	-----1-----	-----1-----
* torque curve no. 2			LB1-2592
*	-----1-----	-----1-----	-----1-----
1352000	2	2	LB1-2593
1352001	0.000000e+00	-6.700000e-01	*LB1-2594
1352002	4.000000e-01	-2.500000e-01	*LB1-2595
1352003	5.000000e-01	1.500000e-01	*LB1-2596
1352004	7.372550e-01	5.265860e-01	*LB1-2597
1352005	7.680490e-01	6.065940e-01	*LB1-2598
1352006	8.672300e-01	7.436600e-01	*LB1-2599
1352007	1.000000e+00	1.000000e+00	*LB1-2600
*	-----1-----	-----1-----	-----1-----
* torque curve no. 3			LB1-2601
*	-----1-----	-----1-----	-----1-----
1352100	2	3	*LB1-2602
1352101	-1.000000e+00	1.984300e+00	*LB1-2603
1352102	-8.009600e-01	1.394000e+00	*LB1-2604
1352103	-6.063800e-01	1.097500e+00	*LB1-2605
1352104	-4.068600e-01	8.220000e-01	*LB1-2606
1352105	-1.992800e-01	6.648000e-01	*LB1-2607
1352106	0.000000e+00	6.032000e-01	*LB1-2608
*	-----1-----	-----1-----	-----1-----
* torque curve no. 4			*LB1-2609
*	-----1-----	-----1-----	-----1-----
1352200	2	4	*LB1-2610
1352201	-1.000000e+00	1.984300e+00	*LB1-2611
*	-----1-----	-----1-----	-----1-----

1352603	-8.000000e-02	-8.000000e-01	*LB1-2661
1352604	0.000000e+00	-6.700000e-01	*LB1-2662
*----	-----1-----	-----1-----1-----	LB1-2663
* two - phase multiplier data from 13-6 test data			LB1-2664
*----	-----1-----	-----1-----1-----	LB1-2665
* head curve			LB1-2666
*----	-----1-----	-----1-----1-----	LB1-2667
1353000	0		*LB1-2668
1353001	0.000000e+00	0.000000e+00	*LB1-2669
1353002	1.000000e-01	0.000000e+00	*LB1-2670
1353003	2.000000e-01	1.000000e-01	*LB1-2671
1353004	3.000000e-01	2.000000e-01	*LB1-2672
1353005	3.500000e-01	3.000000e-01	*LB1-2673
1353006	4.000000e-01	6.000000e-01	*LB1-2674
1353007	5.000000e-01	6.000000e-01	*LB1-2675
1353008	6.000000e-01	6.000000e-01	*LB1-2676
1353009	7.000000e-01	6.000000e-01	*LB1-2677
1353010	8.000000e-01	5.000000e-01	*LB1-2678
1353011	9.000000e-01	3.000000e-01	*LB1-2679
1353012	1.000000e+00	0.000000e+00	*LB1-2680
*----	-----1-----	-----1-----1-----	LB1-2681
* torque curve			LB1-2682
*----	-----1-----	-----1-----1-----	LB1-2683
1353100	0		*LB1-2684
1353101	0.000000e+00	0.000000e+00	*LB1-2685
1353102	1.000000e-01	0.000000e+00	*LB1-2686
1353103	2.000000e-01	1.000000e-01	*LB1-2687
1353104	3.000000e-01	3.000000e-01	*LB1-2688
1353105	3.500000e-01	5.000000e-01	*LB1-2689
1353106	4.000000e-01	7.500000e-01	*LB1-2690
1353107	5.000000e-01	7.500000e-01	*LB1-2691
1353108	6.000000e-01	7.500000e-01	*LB1-2692
1353109	7.000000e-01	7.500000e-01	*LB1-2693
1353110	8.000000e-01	7.500000e-01	*LB1-2694
1353111	9.000000e-01	5.000000e-01	*LB1-2695
1353112	1.000000e+00	0.000000e+00	*LB1-2696
*----	-----1-----	-----1-----1-----	LB1-2697
* pump 2-phase difference data			LB1-2698
*----	-----1-----	-----1-----1-----	LB1-2699
* head curve no. 1			LB1-2700
*----	-----1-----	-----1-----1-----	LB1-2701
1354100	1	1	*LB1-2702
1354101	0.000000e+00	1.000000e+00	*LB1-2703

1354505	8.000000e-01	-1.190000e+00	*LB1-2747
1354506	1.000000e+00	-1.470000e+00	*LB1-2748
*----	-----1-----	-----1-----1-----	LB1-2749
* head curve no. 6			
*----	-----1-----	-----1-----1-----	LB1-2750
1354600	1	6	LB1-2751
1354601	0.000000e+00	1.100000e-01	*LB1-2752
1354602	1.000000e-01	1.300000e-01	*LB1-2753
1354603	2.500000e-01	1.500000e-01	*LB1-2754
1354604	4.000000e-01	1.300000e-01	*LB1-2755
1354605	5.000000e-01	7.000000e-02	*LB1-2756
1354606	6.000000e-01	-4.000000e-02	*LB1-2757
1354607	7.000000e-01	-2.300000e-01	*LB1-2758
1354608	8.000000e-01	-5.100000e-01	*LB1-2759
1354609	9.000000e-01	-9.100000e-01	*LB1-2760
1354610	1.000000e+00	-1.470000e+00	*LB1-2761
*----	-----1-----	-----1-----1-----	LB1-2762
*----	-----1-----	-----1-----1-----	LB1-2763
* head curve no. 7			
*----	-----1-----	-----1-----1-----	LB1-2764
1354700	1	7	LB1-2765
1354701	-1.000000e+00	0.000000e+00	*LB1-2766
1354702	0.000000e+00	0.000000e+00	*LB1-2767
*----	-----1-----	-----1-----1-----	LB1-2768
* head curve no. 8			
*----	-----1-----	-----1-----1-----	LB1-2769
1354800	1	8	LB1-2770
1354801	-1.000000e+00	0.000000e+00	*LB1-2771
1354802	0.000000e+00	0.000000e+00	*LB1-2772
*----	-----1-----	-----1-----1-----	LB1-2773
* torque curve no. 1			
*----	-----1-----	-----1-----1-----	LB1-2774
1354900	2	1	LB1-2775
1354901	0.000000e+00	1.000000e+00	*LB1-2776
1354906	1.000000e+00	1.000000e+00	*LB1-2777
*----	-----1-----	-----1-----1-----	LB1-2778
* torque curve no. 2			
*----	-----1-----	-----1-----1-----	LB1-2779
1355000	2	2	*LB1-2780
1355001	0.000000e+00	1.000000e+00	*LB1-2781
1355007	1.000000e+00	1.000000e+00	*LB1-2782
*----	-----1-----	-----1-----1-----	LB1-2783
* torque curve no. 3			
*----	-----1-----	-----1-----1-----	LB1-2784
1355000	0.000000e+00	1.000000e+00	*LB1-2785
1355007	1.000000e+00	1.000000e+00	*LB1-2786
*----	-----1-----	-----1-----1-----	LB1-2787
* torque curve no. 3			
*----	-----1-----	-----1-----1-----	LB1-2788
1355000	0.000000e+00	1.000000e+00	LB1-2789

1355100	2	3	*LB1-2790
1355101	-1.000000e+00	1.984300e+00	*LB1-2791
1355102	-8.009600e-01	1.394000e+00	*LB1-2792
1355103	-6.063800e-01	1.097500e+00	*LB1-2793
1355104	-4.068600e-01	8.220000e-01	*LB1-2794
1355105	-1.992800e-01	6.648000e-01	*LB1-2795
1355106	0.000000e+00	6.032000e-01	*LB1-2796
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2797			
* torque curve no. 4			
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2799			
1355200	2	4	*LB1-2800
1355201	-1.000000e+00	1.984300e+00	*LB1-2801
1355202	-8.223400e-01	1.830800e+00	*LB1-2802
1355203	-6.337100e-01	1.682400e+00	*LB1-2803
1355204	-4.585300e-01	1.557000e+00	*LB1-2804
1355205	-2.670230e-01	1.436200e+00	*LB1-2805
1355206	-1.761070e-01	1.387900e+00	*LB1-2806
1355207	-8.931000e-02	1.348100e+00	*LB1-2807
1355208	0.000000e+00	1.233610e+00	*LB1-2808
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2809			
* torque curve no. 5			
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2811			
1355300	2	5	*LB1-2812
1355301	0.000000e+00	-4.500000e-01	*LB1-2813
1355302	4.000000e-01	-2.500000e-01	*LB1-2814
1355303	5.000000e-01	0.000000e+00	*LB1-2815
1355304	1.000000e+00	3.569000e-01	*LB1-2816
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2817			
* torque curve no. 6			
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2819			
1355400	2	6	*LB1-2820
1355401	0.000000e+00	1.233610e+00	*LB1-2821
1355402	9.064300e-02	1.196500e+00	*LB1-2822
1355403	1.885690e-01	1.109600e+00	*LB1-2823
1355404	2.734700e-01	1.041600e+00	*LB1-2824
1355405	4.586690e-01	8.958000e-01	*LB1-2825
1355406	5.744800e-01	7.807000e-01	*LB1-2826
1355407	7.381600e-01	6.134000e-01	*LB1-2827
1355408	7.685200e-01	5.849000e-01	*LB1-2828
1355409	8.700570e-01	4.877000e-01	*LB1-2829
1355410	1.000000e+00	3.569000e-01	*LB1-2830
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2831			
* torque curve no. 7			
*-----1-----1-----1-----1-----1-----1-----1-----1----- LB1-2832			

*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2833
1355500	2	7						*LB1-2834
1355501	-1.000000e+00	-1.000000e+00						*LB1-2835
1355502	-3.000000e-01	-9.000000e-01						*LB1-2836
1355503	-1.000000e-01	-5.000000e-01						*LB1-2837
1355504	0.000000e+00	-4.500000e-01						*LB1-2838
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2839
* torque curve no. 8								LB1-2840
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2841
1355600	2	8						*LB1-2842
1355601	-1.000000e+00	-1.000000e+00						*LB1-2843
1355602	-2.500000e-01	-9.000000e-01						*LB1-2844
1355603	-8.000000e-02	-8.000000e-01						*LB1-2845
1355604	0.000000e+00	-6.700000e-01						*LB1-2846
*----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	-----1-----	LB1-2847
*								LB1-2848
..... RELAP5/Mod2 inputdeck (Mk. 6-00 C)								*LB1-2849



BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

2. TITLE AND SUBTITLE

Post-Test-Analysis and Nodalization Studies of OECD LOFT Experiment LP-LB-1
RELAP5/MOD2 CY36-02

5. AUTHOR(S)

D. Lubbesmeyer

8. PERFORMING ORGANIZATION - NAME AND ADDRESS (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

Paul Scherrer Institute (PSI)
Wurenlingen and Villigen
5232 Villigen PSI
Switzerland

9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

This report presents the results and analysis of ten post-test calculations of the experiment LP-LB-1 by using the RELAP5/MOD2 CY36-02 computer code with different nodalizations. Starting with the "standard nodalization" we have reduced the number of volumes and junctions as well as the number of radial zones in the fuel rods. Only small discrepancies have been observed between the results of calculations using different nodalizations. Reduced numbers of volumes and junctions usually have decreased the running time of the problem. The time behaviors of the cladding temperatures have been significantly affected by the chosen nodalizations but surprisingly, the results for the cases with a reduced number of volumes and junctions seem to be slightly closer to the experimental data. With respect to top-down rewetting, one of the key-events of Experiment LP-LB-1 during the blow-down phase, RELAP5/MOD2 was not at all able to predict this phenomenon.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

RELAPS/MOD2, LP-LB-1

1. REPORT NUMBER
(Assigned by NRC, Add Vol., Supp., Rev.,
and Addendum Numbers, if any.)

NUREG/IA-0089
PSI-Bericht Nr. 91

3. DATE REPORT PUBLISHED

MONTH	YEAR
October	1992

4. FIN OR GRANT NUMBER

A4682

6. TYPE OF REPORT

Technical

7. PERIOD COVERED (inclusive Dates)

13. AVAILABILITY STATEMENT

Unlimited

14. SECURITY CLASSIFICATION

(This Paper)

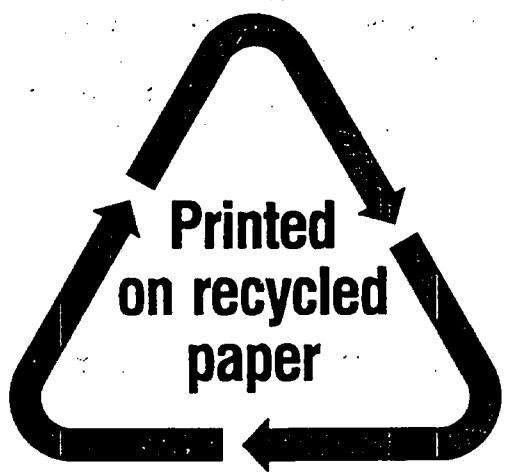
Unclassified

(This Report)

Unclassified

15. NUMBER OF PAGES

16. PRICE



Federal Recycling Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, \$300

SPECIAL FOURTH-CLASS RATE
POSTAGE AND FEES PAID
USNRC
PERMIT NO. G-67

120555063572 4 1AN1CI
US NRC-RES
DIV OF SYSTEMS RESEARCH
BRANCH CHIEF
REACTOR & PLANT SYSTEMS BR
NL/N-353
WASHINGTON DC 20555